# Sustainable Transport Planning

## A Multi-Methodology Approach to Decision Making

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PhD Thesis

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**DTU Transport**
Department of Transport

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# Preface

This PhD thesis is the result of a 3 year PhD study entitled "Sustainable Transport Planning - a Multi-Methodology Approach to Decision Making". The study is financed by a DTU scholarship and has been conducted from October 2006 to November 2009 at the Department of Transport (DTU Transport) formerly known as the Centre for Traffic and Transport (CTT), at the Technical University of Denmark (DTU). The PhD study has been supervised by Professor Steen Leleur.

My travel through the PhD study has been interesting, challenging and educating. The PhD study has taken me to several places, of both geographic and personal kind, and has been of great value to me. I have met many people, among these many researchers and fellow PhD students, some are now dear friends. Throughout the PhD study I have had the opportunity to follow several courses on different universities both in Denmark and abroad. I have also enjoyed productive visits at Manchester Metropolitan University Business School in February and March 2008 and at Hull University Business School, Centre for Systems Studies in May 2008. During these visits, I have met many interesting and highly skilled researchers, with whom I have had many inspiring conversations. Specifically, I would especially like to thank Senior-lecturer, Dr. Alberto Paucar-Caceres in Manchester and Director of Centre for Systems Studies, Dr. Jennifer Wilby in Hull as they have shown me exceptional attention and have helped me to gain the most from my stays abroad. They have, as well, introduced me to a number of fantastic researchers from whom I have learned a lot. Furthermore, I find it important to mention that attending Lugano Summer School of Systems Design in June 2008 has been of great value to me, as the learning environment, and the lectures by and discussions with Professor Peter Checkland and Professor Werner Ulrich have been very inspiring.

Finally, I would like to thank my colleagues, friends, and family for their comments, good discussions, and continuous support during the PhD study. Special thanks go to my colleagues Maria J. Figueroa, Alex Landex, Michael B. Barfod, to my proof-readers Ulla Salado-Jimena, Karin K. Jørgensen, Henriette Lindebjerg, to my parents, and to my dear Martin. Last, but not least, I would like to thank my supervisor Professor Steen Leleur for encouraging me to apply for the PhD scholarship in the first place and for many hours of interesting discussions and support when needed.

Sara Lise Jeppesen, 30th of November 2009

# Abstract in English

This PhD thesis with the title 'Sustainable Transport Planning - A Multi-Methodology Approach to Decision Making' concerns an operationalisation of the three dimensions (social, economic, and environmental) of the concept of sustainability within transport planning. The thesis considers why 'traditional transport planning' based on a systematic approach is not sufficient to deal with an operationalisation of the concept of sustainability in transport planning and the influence this can have on the complexity level of the planning problems. It is on this basis illustrated that a systemic approach to transport planning could be useful within an exploration of the use of the concept of sustainability within strategic and complex transport planning problems. Methodologies and theory for supporting a systemic approach are found within systems thinking and are applied to transport planning using multi-methodology in the approach. This is used to define, understand, and address different types of complexity and problem types which are found in sustainable transport planning.

In the PhD thesis it has been illustrated that the concept of sustainability can be interpreted in different ways, ranging from being merely a word, over somewhat of a paradigm, and further on being as specific as a result. The concept of sustainability used in this PhD thesis is based on the definitions made in the Brundtland report and previous research relating sustainability with systems thinking. This PhD thesis has three main focuses concerning the concept of sustainability in transport planning:

- How the concept of sustainability can be operationalised
- Considerations of whether an implicit or explicit use is applied
- Recognising if the concept of sustainability is applied to 'process' and/or to 'results'

During this PhD thesis, four methodology developments have been accomplished in relation to the exploration of an operationalisation of the concept of sustainability. The methodology developments are based on three well-known methodologies: Critical Systems Heuristics (CSH), Decision Conference (DC), and Soft Systems Methodology (SSM). The methodologies are chosen after scrutinising previous research where the methodologies were applied in similar use and research fields. These known methods have been altered to concern the need and possibilities within transport planning, with a special focus upon operationalising the concept of sustainability. The proposed methodology developments are named:

- Semi-Soft methods
- Critical Soft Systems Framework (CSSF)
- Decision Simulation Technique (DST)
- Short Decision Conference (SDC)

Semi-Soft methods and CSSF represent a way of operationalising the concept of sustainability in an implicit way and DST and SDC represent a way of operationalising the concept of sustainability in an explicit way. Each of the four developed methodologies provides input for operationalising the concept of sustainability in transport planning and their potential are summarised using SWOT-matrixes. Applications of the developed methods are demonstrated by four case studies which are described in four of the five papers written during this PhD study.

Based on the methodology developments an outline of some guidelines for sustainable transport planning is suggested. The guidelines are sorted into three categories, one concerning the problem situation, one concerning a sustainable planning process, and one concerning sustainable results. These guidelines are seen as an initial step towards an operationalisation of the concept of sustainability and as a help for transport planners and decision makers seeking a transparent and operationalised use of the concept of sustainability. The guidelines developed in the PhD thesis are related to different planning types and levels. These constitute a link between the defined either 'process' or 'result' oriented application of the concept of sustainability and the actual transport planning levels found in Danish transport planning. The contributions of this PhD thesis are therefore:

- Examples of how systems thinking and multi-methodology can be used to operationalise the three dimensions of the concept of sustainability within transport planning
- Four methodology developments
- Suggestions of how the concept of sustainability can be operationalised through either an implicit or an explicit approach
- Suggestions of considering if the concept is applied to the process or the result
- Initial outline of a set of guidelines for sustainable transport planning

Finally, this PhD thesis concludes that the concept of sustainability can be operationalised through a systems thinking approach, and that it is possible to outline a set of guidelines for transparent and operational use of the concept of sustainability within different levels of transport planning.

# Abstract in Danish (dansk resume)

Denne Ph.D.-afhandling med titlen ”Bæredygtig transportplanlægning - en multi-metode tilgang til beslutningstagning” omhandler en operationalisering af de tre dimensioner (social, økonomisk, og miljømæssig) af bæredygtighedsbegrebet i transportplanlægning. Afhandlingen omhandler, hvorfor ’traditionel transportplanlægning’ baseret på en systematisk planlægningstilgang ikke er tilstrækkelig til at håndtere en operationalisering af bæredygtighedsbegrebet i transportplanlægning og den indflydelse, det kan have på planlægningsproblemernes kompleksitets niveau. Det er på denne baggrund illustreret at en systemisk tilgang til transportplanlægning kan være brugbar i forbindelse med en undersøgelse af bæredygtighedsbegrebets brug i forbindelse med strategiske og komplekse transportplanlægningsproblemer. Metoder og teori, der understøtter en systemisk tilgang, findes i systemtænkning og er anvendt i transportplanlægning ved brug af en multi-metode tilgang. Dette er brugt til at definere, forstå og adressere forskellige kompleksitets- og problemtyper, som kan findes i bæredygtig transportplanlægning.

Det er i denne Ph.D.-afhandling illustreret, at bæredygtighedsbegrebet kan fortolkes på forskellig vis, strækkende sig fra ikke at være meget mere end et ord, over et paradigme, og videre til at være et specifikt resultat. Bæredygtighedsbegrebet er i denne Ph.D. afhandling anvendt baseret på definitionerne fra Brundtland rapporten og på tidligere forskning, der kæder bæredygtighed sammen med systemtænkning. Denne Ph.D.-afhandling har tre hovedfokusområder vedrørende bæredygtighed:

- Hvordan kan bæredygtighedsbegrebet blive operationaliseret
- Overvejelser om anvendelse af en enten implicit og eksplicit brug
- Erkende om bæredygtighedsbegrebet skal anvendes i forbindelse med ’proces’ eller ’resultat’

I løbet af denne Ph.D.-afhandling er der gennemført fire metodeudviklinger i relation til en undersøgelse af en operationalisering af bæredygtighedsbegrebet. Metodeudviklingerne er baseret på tre kendte metoder: Critical Systems Heuristics (CSH), Decision Conferences (DC), og Soft Systems Methodology (SSM). Metoderne er valgt efter en gennemgang af tidligere forskning, hvor metoderne blev anvendt til lignende brug og forskningsfelter. Disse kendte metoder er blevet udviklet, så de indeholder de behov og muligheder der findes i transportplanlægning, med et særligt fokus på en operationalisering af bæredygtigheds-begrebet. De foreslåede metodeudviklinger kaldes:

- Semi-Soft methods
- Critical Soft Systems Framework (CSSF)
- Decision Simulation Technique (DST)
- Short Decision Conferences (SDC)

Semi-Soft methods og CSSF repræsenterer en implicit måde, hvorpå bæredygtighedsbegrebet kan operationaliseres og DST og SDC repræsenterer en eksplicit måde, hvorpå bæredygtighedsbegrebet kan operationaliseres. Hver af de fire udviklede metoder giver input til en operationalisering af bæredygtighedsbegrebet i transportplanlægning og deres potentiale er summeret ved brug af SWOT-matricer. Brugen af de udviklede metoder er demonstreret i de fire case-studier, som er beskrevet i fire af de fem papirer, der er skrevet i løbet af dette Ph.D.-studium.

Baseret på metodeudviklingerne er der foreslået et udkast til nogle retningslinjer for bæredygtig transportplanlægning. Retningslinjerne er fordelt på tre kategorier: en, der omhandler problemsituationen, en, der omhandler en bæredygtig planlægningsproces, og en, der omhandler bæredygtige resultater. Disse retningslinjer skal ses som et første skridt i retning af en operationalisering af bæredygtighedsbegrebet og en hjælp til transport-planlæggere og beslutningstagere, som søger en gennemsigtig og operationel brug af bæredygtighedsbegrebet. De udviklede retningslinjer er i Ph.D.-afhandlingen relateret til forskellige planlægningstyper og -niveauer. Disse konstituerer et link mellem den definerede 'proces'- eller 'resultat'-orienterede brug af bæredygtighedsbegrebet af de faktiske transportplanlægningsniveauer, som findes i dansk transportplanlægning. Denne Ph.D.-afhandlings bidrag er derfor:

- Eksempler på hvordan systemtænkning og multiple-metoder kan anvendes til at operationalisere de tre dimensioner af bæredygtighedsbegrebet i transportplanlægning
- Fire metodeudviklinger
- Forslag til, hvordan bæredygtighedsbegrebet kan operationaliseres gennem enten en implicit eller en eksplicit tilgang
- Forslag om at overveje om bæredygtighedsbegrebet anvendes på 'proces' eller 'resultat'
- Et første udkast til et sæt retningslinjer for bæredygtig transportplanlægning

Afslutningsvis konkluderer denne Ph.D.-afhandling, at bæredygtighedsbegrebet kan operationaliseres via en systemtænknings tilgang, og at det er muligt at skitsere et sæt retningslinjer, som det foreslås brugt for at opnå en gennemsigtig og operationel anvendelse af bæredygtighedsbegrebet på forskellige niveauer af transportplanlægningen.

# Content

# Abbreviations

The acronyms found below are used throughout this thesis. They are presented by their full name when they are first used but will later on be referred to by their acronym. In the list below the acronyms are presented in alphabetical order. The list is thought as a help for the reader if a need for refreshing the full name of an acronym after its first introduction should occur.

| Acronym | Full name |
|---|---|
| ABCD approach | Awareness, Baseline mapping, Creating a vision, Down to action |
| AHP | Analytical Hierarchy Process |
| B/C-rate | Benefit/Cost-rate |
| CATWOE | Customer, Actor, Transformation, Weltanschauung/Worldview, Owner, Environmental constraints |
| CBA | Cost-Benefit Analysis |
| CDM | Customised Decision Models |
| COSIMA | COmpoSIte Model for Assessment |
| CPS | Creative Problem Solving |
| CSH | Critical System Heuristics |
| CSSF | Critical Soft Systems Framework |
| CST | Critical Systems Thinking |
| DC | Decision Conference |
| DST | Decision Simulation Technique |
| EIA | Environmental Impact Assessment |
| EC | European Commission |
| FW | Futures Workshop |
| ISSS | International Society for the Systems Sciences |
| MCA | Multi-Criteria Analysis |
| MCDA | Multi-Criteria Decision Analysis |

| | |
|---|---|
| NGO | Non Governmental Organisation |
| OR | Operations Research |
| PACDAW | Process, Affectee, Constraints, Decision-maker, Actor, Weltanschauung/Worldview |
| RAEng | Royal Academy of Engineering |
| REMBRANDT | Ratio Estimations in Magnitudes or deci-Bells to Rate Alternatives which are Non-DominaTed |
| ROD | Rank Order Distribution |
| RPM | Rational Planning Model |
| SDC | Short Decision Conference |
| SMARTER | Simple Multi-Attribute Rating Technique Exploiting Ranks |
| SSM | Soft Systems Methodology |
| TNS | The Natural Step |
| TRR | Total Rate of Return |
| VC | Vision Conference |
| VF | Value Function |
| UKSS | United Kingdom Systems Society |
| UN | United Nations |

# 1 Introduction

The transport system is important for our society. Almost everything we do is related to some aspect of transport. The transport system provides us with the goods we require and takes us to work and leisure activities etc. Transport is an essential part of everyday life, and it is the backbone around which our society has developed – a transport planner[1] even said: "transport is the glue that keeps everything together". We have indirectly chosen to be dependent on the ability to transport goods and persons, or at least we have no obvious possibility to change this pattern. Instead we seek to integrate the transport infrastructure in the best possible way minimising the negative transport impacts (e.g. accidents, noise, emissions etc.) as much as possible.

Acknowledging the importance of transport in our daily life, we know that we cannot keep up our present way of living without it, nor is it easy to revolutionise it or just reduce it. Laws and regulations have been imposed to ensure high quality planning processes (Miljøministeriet, 2007) and advanced tools have been developed to assess planning proposals and their impact. However, we still face major problems related to transport (e.g. congestion, land use, sustainability operationalisation etc.). These problems are not easily dealt with. The transport planning process, the assessment tools, the decision making processes and the legislation undergo continuous development, affecting the users, their attitudes and the perceived and measured impacts. Still more has to be done to keep up with the challenges of the increasing transport needs and impacts. Therefore this PhD thesis contributes with a multi-methodology approach to decision making designed to explicate and operationalise the three dimensions of the concept of sustainability (social, economic, and environmental) (UN,1987) and to provide guidelines for how to obtain 'Sustainable Transport Planning'.

## *1.1 Research questions*

The complexity level of transport planning and transport problem situations has increased substantially over the years. The increasing complexity is among other things a result of

[1] From conversation with Roy McDonald and Jean Laurie at Greater Manchester Passenger Transport Executive (GMPTE), during my stay at Manchester Metropolitan University Business School (MMUBS) in the spring of 2008

constraints, impacts, and stakeholders. These factors have a vital role in the shift of planning needs which can be seen in recent years' planning, see (Jeppesen & Pedersen, 2005). To a large extent the present planning problems cannot be solved by 'traditional' planning based on a systematic approach, but is as argued in this thesis in need of a 'complex' planning approach based on a systemic mindset, see (Leleur, 2008). The complexity level makes the problem situations more difficult to understand and assess and can make the process seem unclear for the involved and affected stakeholders. This can have large consequences for the transport planners and the decision makers as it, among other complicated issues, can lead to prolonged planning and decision making processes as seen in connection with, for example, the great bridge projects in Denmark.

The increase in negative impacts from the transport sector has helped to establish awareness about areas such as global impacts and climate issues. The concept of sustainability is often brought forward in relation to these issues and the concept is therefore often found in visions and planning documents for the transport sector (e.g. national plans, municipality plans, local plans etc.). The concept is applied both on the global, national, regional and local levels. However, common for all levels are the difficulties of transforming the concept from words to action, and thereby making the concept operational. Implementation of the concept of sustainability in transport planning is not simple. It depends on different stakeholders and their preferences towards both measurable (hard) and immeasurable (soft) criteria. Dealing with soft criteria and information adds to the already increasing complexity level of transport planning situations.

Dealing with complexity and sustainability is difficult within the existing conventional planning process. Planning as an activity therefore needs to be developed and transformed in order to cope with both the operationalisation of the concept of sustainability and the rising complexity level of planning problems. To deal with this, new ways of decision support which can relate to sustainability, communicate the findings derived from implementation of a complex approach to transport planning, and cope with the perceived complexity level are needed. Such decision support should provide planners and decision makers with the broadest possible understanding of the 'wider' problem situation, its relations, and constraints.

A systemic approach to transport planning seems to hold the necessary mindset to cope with the complexity level. Furthermore, a multi-methodology approach as used in systemic planning could provide some of the necessary tools, leading to new planning schemes, appraisal methodologies and types of decision support.

This PhD work demonstrates how transport planning can be developed using ideas from systems thinking to operationalise some of the processes. Furthermore, the concept of sustainability is explored and operationalised for the transport planning process using ideas based on systems thinking. The choice of relevant methodology is examined and explained, and afterwards some methodology development is conducted resulting in a proposal of 4 new approaches. Furthermore links between transport planning, systems thinking and sustainability are illustrated. Therefore the focus of the thesis is framed by the two following research questions:

1. How can the concept of sustainability be implemented and operationalised in strategic transport planning and decision making?

2. Is it possible to formulate some guidelines for sustainable transport planning in order to analyse complex and strategic transport planning problems?

## *1.2 The structure of the PhD thesis work*

A general overview of the structure of this thesis can be gained from Figure 1, where the dark green boxes refer to the main contents of the chapters and the light green boxes refer to the topics of the chapters.

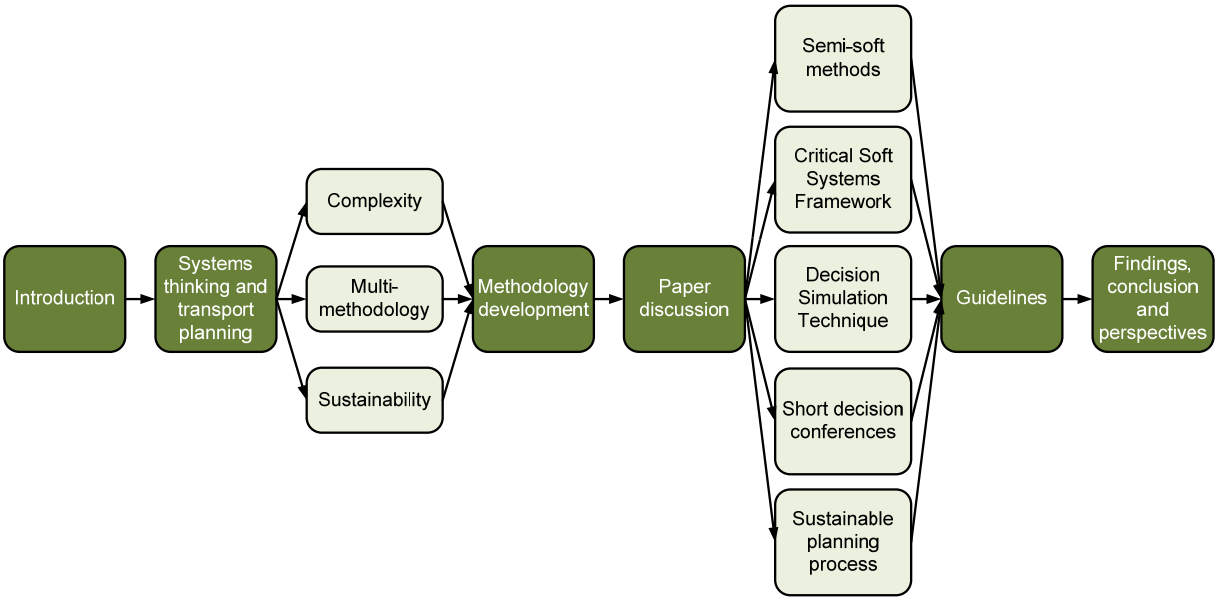


**Figure 1 Thesis structure**

Specifically, the thesis is structured as follows:

**Chapter 1** presents the purpose and outline of this PhD thesis. This includes an outline of the key research questions of the thesis, followed by an outline of the thesis content.

**Chapter 2** presents the relation between systems thinking and transport and it is described how and why systems thinking is applicable and beneficial for complex transport planning. The different paradigms of systems thinking are addressed. As a result of the systemic approach to problem solving and the use of systems thinking, multi-methodology is introduced as a tool. The concept of sustainability is presented and relations between systems thinking and the concept of sustainability are described. Finally a set of applicable methods is listed and three of those are chosen for the further work.

**Chapter 3** presents a multi-methodological approach to an operationalisation of the concept of sustainability based on the methods developed in this thesis: Semi-Soft methods, Critical Soft Systems Framework (CSSF), Decision Simulation Technique (DST) and Short Decision Conferences (SDC). Specifically the content of the four proposed methodology developments is presented and discussed in relation to their use and application.

**Chapter 4** presents the scope and findings of the five enclosed papers and provides an outline of the paper impact areas. This is followed by an outline of the five papers presented in this PhD thesis. The papers are presented by a main description of their purpose and the main findings. The full papers are also to be found in this chapter.

**Chapter 5** presents the set of guidelines for an operationalisation of the concept of sustainability suggested in this thesis. The sustainability-operationalisation is focused on the process and the results, respectively. The two approaches are related to Danish transport planning levels.

Finally, **Chapter 6** presents the findings of the PhD thesis. The findings lead to the answers to the research questions presented in Chapter 1. These answers are followed by conclusions and perspectives of the work.

**Appendix 1** contains a description of the COSIMA decision model. The appendix outlines the methods and processes found in the COSIMA decision model. This appendix enables a better understanding of the COSIMA decision model in relation to its use in the Decision simulation Technique (DST) described in Chapter 3 and in paper 3, and for the Decision Conferences (DCs) described in Chapter 3 and paper 4. **Appendixes 2 and 3** provide memorandums of the two conducted decision conferences, reported in the case studies used in papers 3 and 4.

# 2 A systems approach to transport planning and the concept of sustainability

This chapter presents some of the main ideas and concepts of systems thinking which is of relevance for transport planning. A presentation of systems and systems ideas is provided to illustrate how and why systems ideas can be beneficial for transport planning. Systems ideas are among other things used to address the complex problem situations often encountered in transport planning, and thoughts are given to different problem types and approaches. The concept of sustainability is presented and related to systems thinking and transport planning. Systems thinking is subsequently used as a mean to operationalise the concept of sustainability within transport planning. Finally, the methodologies which have been applied in the thesis are presented. Throughout this PhD thesis a number of different methodologies are used either solitarily or jointly in multi-methodology approaches.

## *2.1 Systems and systems thinking*

Systems and systems thinking have been applied in many different fields, both in academia and in practice. To approach problem situations as a whole by working within a systems thinking framework requires an understanding of what a system is. There are many definitions of 'systems', see among others (Checkland, 1993/1999), (Jackson, 2000), (RAEng, 2007).

It is in this thesis chosen to present the systems definition provided by the United Kingdom Systems Society (UKSS):

*"The concept of system embodies the notion of a collection of elements connected together to form a whole. Systems thinking uses this concept to help understand the world. Central to the approach are the ideas of emergence and hierarchy, and communication and control. Systems practice employs systems ideas to design and manage complex processes and artefacts for the benefit of individuals, organisations and society."* (UKSS, 2003).

Flood & Jackson have described the properties of simple and complex systems, respectively. The two classifications are as follows (Flood & Jackson, 1991, pp 33-34):

| Simple systems are characterised by | Complex systems are characterised by |
|---|---|
| • A small number of elements<br>• Few interactions between elements<br>• Attributes of the elements are predetermined<br>• Interaction between elements is highly organised<br>• Well-defined laws govern behaviour<br>• The 'system' does not evolve over time<br>• 'Sub-systems' do not pursue their own goals<br>• The 'system' is unaffected by behavioural influences<br>• The 'system' is largely closed to the environment | • A large number of elements<br>• Many interactions between the elements<br>• Attributes of the elements are not predetermined<br>• Interaction between elements is loosely organised<br>• They are probabilistic in their behaviour<br>• The 'system' evolves over time<br>• 'Sub-systems' are purposeful and generate their own goals<br>• The 'system' is subject to behavioural influences<br>• The 'system' is largely open to the environment |

**Table 1 Definitions of simple and complex systems as according to Flood & Jackson, adapted from (Flood & Jackson, 1991, pp. 33-34)**

In his short description of the three main pillars of Critical Systems Heuristics (CSH)[2], Werner Ulrich describes the usefulness of the systems pillar as:

*"Systems thinking is relevant because all problem definitions, solution proposals, evaluations of outcomes, and so on, depend on prior judgments about the relevant 'whole system' to be looked at. Improvement, for instance, is an eminently systemic concept, for unless it is defined with reference to the entire relevant system, sub-optimisation will occur."* (Ulrich, 2005, p. 1).

With these definitions of 'systems', simple and complex systems properties, and the relevance of systems thinking it is found that systems are useful in relation to understanding the problems ahead. Especially in relation to understanding that problems might have sub problems which are interrelated and that a problem might be a symptom of some other problem. The definitions and usefulness of a systems approach are furthermore described by the need for appreciating different worldviews held by both involved and affected stakeholders. Another important property of systems thinking is the notion of emergent properties, as these properties describe the benefits found by approaching the system/problem situation as a whole. This has been described by Midgley (2000) as:

*"An emergent property is one that results from the interaction of a system as a whole rather than from one or two of its parts in isolation." (Midgley, 2000, p. 40).*

[2] which will be presented and used later in this thesis

Such emergent properties can be difficult to predict as they occur as a result of more than the sum of the parts of the system and can be of both a positive and negative character (Midgley, 2000) and (RAeng, 2007). Midgley (2000) describes the emergent properties of transport systems as follows.

*"... the road transport systems has its own more general emergent properties too, such as the movement of people and goods from one place to another (enabling all kinds of activities that would otherwise be impossible); pollution; and a reduction in the measured intelligence of children living with high levels of lead emissions. Each of these properties of the road transport system comes about precisely because it functions as a system – as an organised whole." (Midgley, 2000, p. 40).*

From the quote of Midgley (2000) it is shown that transport and thereby transport planning can be seen as a system and that systems thinking could be useful for approaching transport planning problems. The description of the emergent properties of the transport systems reveals that these can be both positive and negative, that they can be difficult to predict and that these emergent properties too can influence the complexity level of transport planning and decision making.

### 2.1.1 Systems thinking paradigms and approaches

Systems thinking has developed over the years and as a result of this there are several approaches and thought patterns which can be followed, known as paradigms. The paradigms have in general evolved as a reaction to the identified shortcomings of previous paradigms. Some work with a simplicity and complexity paradigm as presented by Morin (Leleur, 2008) while others work with four paradigms: Functionalist, interpretive, emancipatory, and post-modern (Jackson, 2000, 2003), see Table 2.

Table 2 furthermore illustrates the approaches associated with the presented paradigms. From the table it can be seen that the simplicity and functionalist paradigms draw on the hard methods found in a systematic approach. The complexity approach as well as the interpretive, emancipatory, and postmodern paradigms is associated with a systemic approach. The individual paradigms are associated with approaches known as soft, critical reflection, creative and a combination of all, see (Jackson, 2000).

From Table 2 it can be seen that there are different approaches and methodology approaches to take to an identified problem situation. The approach can either be systematic or systemic, and be based on hard, soft, critical or creative methods for problem solving. These approaches

can either be seen as separate or as complementing each other, depending on how the use and interpretation of the paradigms are conducted. Hard, soft, critical, and to a little extent creative methods will be used throughout this PhD thesis, the three latter are often simply referred to as 'soft-methods'.

| | | | | |
|---|---|---|---|---|
| **Paradigm** | Simplicity | Complexity | | |
| | Functionalist | Interpretive | Emancipatory | Postmodern |
| **Approach** | Hard | Soft | Critical reflection | Hard, soft, critical reflection, and creative |
| | Systematic | Systemic | | |

**Table 2 Paradigm and approach based on combining classifications from Jackson (2000) and Leleur (2008).**

In general it can said that hard methods are dependent on the ability to be able to count and calculate, soft methods depend on the ability to explore and intervene in the situations (and are not necessarily easy to apply), critical methods depend on the ability to reflect upon own and others norms, values and facts, and creative methods depend upon the ability to be open minded and to engage in e.g. idea generation or new approaches to the given problem situation (Jackson, 2000), (Ulrich, 2005), (Leleur, 2008) and (Vidal, 2009). Some main characteristics are summarised in Table 3.

| Hard methods | Soft methods | Critical methods | Creative methods |
|---|---|---|---|
| • Based in quantitative input<br>• Not participative, but often conducted by analysts/consultants<br>• Finding 'exact' answers<br>• 'Static' in their approach<br>• The 'traditional' approach | • Based on qualitative input<br>• Participative<br>• Do not find 'exact' answers but can be either exploring, interpreting or emancipating or a combination of all<br>• 'Dynamic' in their approach<br>• Well suited for complex situations | • Based on qualitative input<br>• Can be participative<br>• Do not find 'exact' answers but can be reflecting and emancipating<br>• Well suited for complex situations | • Based on qualitative input<br>• Participative<br>• Idea generating<br>• Do not find 'exact' answers but can be either exploring, interpreting or emancipating or a combination of all<br>• 'Dynamic' in their approach<br>• Well suited for complex situations |

**Table 3 some of the characteristics of hard and soft methods**

### 2.1.2 Systematic or systemic approach

Systems thinking aims at providing a theoretical foundation for dealing with ill structured problems of high complexity and can help to categorize the problem type, and provide insights on how to deal with this kind of problems often regarded as messy situations (Flood & Jackson, 1991). A classification of problem type can be helpful in order to design a suitable approach. Several 'classic' problem types are identified and described in the literature, see among others (Leleur, 2008). Among these it is in this PhD thesis chosen to mention some problem types which can be related to messy and complex planning tasks. Here wicked problems and three different change types are addressed. Leleur presents the notions of wicked problems based on the work of Rittel & Webber and the change types based on the work of Stacey, see (Leleur, 2008, pp. 18-20). The descriptions are shortly summarised below:

- **Wicked problems** can be seen as very complex problems which are symptoms of other problems. Wicked problems have not got a specific formulation, and are all unique. Solutions are seen as 'one-shot operations' which can be good-or-bad, rather than true-or-false, and there are no tests of the solutions.

- **Closed, contained, and open-ended changes** define three kinds of problem types. The three problem types rank from the closed change defining unambiguous problems which can be dealt with in a traditional manner as rational decision-making techniques can be used, over contained changes which are problem situations where forecasts can be made based on existing trends and experience, to open-ended changes which are problems where forecasts cannot be used as they are ambiguous and have unknown future consequences.

These problem types can be used to characterise, and later approach the transport planning problems which we see today. Some examples could be problems regarding congestion, lack of maintenance, and operationalisation of the concept of sustainability etc. Furthermore, transport planners, as other problem solvers, are facing new challenges. These are described as follows by Vidal (2009):

*"(...) problem solvers are facing new demands: Problem solving in collaboration with a group of stakeholders. The main qualification in this respect is the ability to facilitate change processes, involving participants actively and being able to regard the problematic situation in relation to a dynamic context of different environments. The essence is the ability to alternate between modes of rationality, reflection and creativity in cooperation with the stakeholders, rather than being locked into one of these modes."* (Vidal, 2009, pp. 409-410).

Inclusion of stakeholders in the process and the need for a dynamic approach are some of the factors which increase the complexity of current problem situations in transport planning. Leleur (2008, pp. 7-16) has outlined three types of complexity which are relevant for (transport) planning:

- **Detail complexity**: regards the data used with relation to the planning problem. The possibility to gather data, the quantity of the employed data, and its quality are concerned and so is the determination of boundaries. Detail complexity can be an aid to operate in 'space' concerning the 'means'. In transport planning this kind of complexity can be related to the difficulties of getting the data needed for the socio-economic assessment models run when prioritising and making decisions about which alternative solutions to choose.

- **Dynamic complexity**: regards changes over time and can be related to the difficulties and uncertainties related with long term planning e.g. foreseeing the needs of times to come, of new generations, and of changing societal patterns etc. Dynamic complexity operates in 'time' concerning 'path'. In transport planning this kind of complexity can for example be related to the difficulties of 50 year plans for new urban development areas and assessments of large infrastructure projects.

- **Preference complexity**: regards interests and preferences of stakeholders, and depend on communication and the need for issues to be brought forward and debated. Preference complexity operates in 'mind' and concerns 'ends'. In transport planning this kind of complexity can relate, for example, to the different worldviews regarding new infrastructure elements. This concerns both large and small elements, some examples of large infrastructure elements for which many viewpoints are found are bridges, bypass roads, metro planning etc.

When all three types of complexity can be related to transport planning at the same time, this can be viewed as 'hypercomplex' and as part of the emerging hyper-complex society identified by the communication researcher Lars Qvortrup (Leleur, 2008).

Presence of all three kinds of complexity can often be the case within transport planning problems. It can often be difficult to obtain the data and information needed for the planning task, and planning tasks can be developed and discussed for a long period before decisions are made as boundaries, values, and norms might change during such a period. Finally there are often many stakeholders involved and affected by a planning task, which thereby become influenced by different worldviews and preferences.

In traditional transport planning, problem situations are approached in a systematic way. This type of approach is not always sufficient when dealing with problem situations which can be characterised as complex; in such a context a systemic approach is needed (Leleur, 2008). The two approaches can briefly be outlined as follows, see Table 2:

- **Systematic approach:** The traditional approach to (transport) planning embedded in the simplicity/functionalist paradigm applying a hard approach to problem solving.

- **Systemic approach:** A complexity based approach to (transport) planning embedded in the complexity/interpretive-emancipatory-postmodern paradigms applying also soft, critical, and creative approaches to problem solving.

To determine, if a problem situation is traditional or complex, a 'litmus test' based on an ideal-typical decision model can be used, see Leleur (2008, p. 33). The litmus test regards seven ordinary tasks in a traditional planning approach, see Table 4. The task concerns among others formulation of the problem situation, identification of alternatives, collection of data and evaluation of consequences, and tests if any of these tasks can cause any problems in a 'traditional' planning approach. Table 4 is used by filling one of the seven statements marked by '*' into the sentence at the (*) mark. If any of the questions is answered with 'maybe' or 'yes' the situation can be said to be of a complex character.

| Litmus test of complexity |
|---|
| **– Will ... (*) ... cause any problems in a 'traditional' planning approach?** |
| * identification and definition of goals and objectives |
| * identification of alternatives |
| * prediction of consequences |
| * evaluation of consequences |
| * decision making based on the above |
| * implementation of decisions |
| * obtaining feedback of the results |

**Table 4 Litmus test of complexity adapted from (Leleur, 2008, p. 33)**

If the problem situation is said to be complex it should be approached in a systemic way. If not it can be regarded as a traditional problem and approached in a systematic way, see Figure 2.

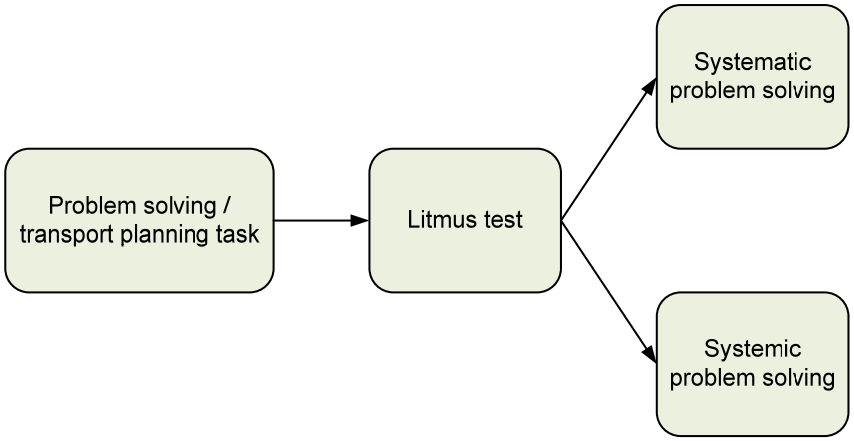


**Figure 2 The use of a litmus test to determine whether a problem situation should be approached in a systematic or a systemic way (Leleur, 2008)**

Transport planning problems are as previously stated getting more and more complex and they therefore often need a systemic approach. The litmus test provides a simple but highly practical tool to identify if a systemic approach is needed. Identification of whether or not a transport related problem can be dealt with by 'traditional' planning (systematic planning) or requires a complexity approach (systemic planning) can be of importance in regard to development of transport planning approaches and procedures. Leleur (2008) provides the following description of a systemic planning approach:

*"What characterises the systemic planning approach is that it seeks to take the complexity and uncertainty – or better: the complexities and uncertainties – into account by scrutinising and combining different methods and processes that may be relevant in the actual planning task"* (Leleur, 2008, p. 32).

As Leleur states in the quote above, a combination of different methods and processes might be beneficial for dealing with a complex problem situation. This leads to the use of multi-methodology as presented in (Mingers & Gill, 1997), see section 2.1.3.

### 2.1.3 Multi-methodology

In the theory of systems thinking it has been discussed whether or not methodologies and methods from different paradigms could or could not be combined and used in joined approaches, see among others (Mingers & Gill, 1997) and (Midgley, 2000). In order to be able to combine methodologies, methods and tools/techniques from different paradigms it can be useful to clarify the definitions of these. Midgley (2000) determines the difference between method and methodology as follows:

*"A 'method' is a set of techniques operated in a sequence (or sometimes iteratively) to achieve a given purpose. A 'methodology' is the set of theoretical ideas that justifies the use of a particular method or methods."* (Midgley, 2000, p. 105).

There are different approaches to the use of theories, methodologies, methods, and techniques developed within the paradigms, depending on the point of reference, and if paradigm borders can or cannot be crossed. This thesis has chosen to follow some of the ideas of multi-methodology, as presented by (Mingers & Gill, 1997) and (Mingers, 2001), allowing methodologies, methods and techniques from different paradigms to be used either alone or in combination. The approach of the thesis can be summarised by the following quotes of Mingers (1997, 2001):

*"(...) all problem situations are complex and multi-dimensional, involving material, social, and personal aspects. An intervention should therefore be more effective if it addresses, within the limitations of time and resource, all of these features. This suggests that, wherever possible, a range of methodologies (or parts thereof), across the paradigms, should always be used. If a problem situation is approached through the perspective of a single methodology (or paradigm) then important aspects will be ignored, or will have to be dealt with in an ad hoc or intuitive way."* (Mingers, 1997, p. 414).

*"Different types of methods, such as hard and soft, focus on particular aspects of the very complex world which decision-makers have to deal with. Therefore, employing more than one method in combination will help to address the different levels and dimensions of a problematic situation."* (Mingers, 2001, p. 289).

According to Mingers there are three main reasons for combining methods in multi-methodology approaches (Mingers, 2001, pp. 289-294):

- The world is multi-dimensional and so are the problem situations encountered
- Interventions are processes consisting of different stages and requirements
- Several approaches to the same task provide a possibility to triangulate results and gain new insights

Methodologies, methods, techniques, and paradigms can be combined in different ways. One is taking one methodology after another and others consist of a 'mix'n'match' approach where methods and techniques are taken from different methodologies and combined into an approach suiting the problem situation in question, see (Mingers, 2001). This PhD thesis will structure and use a combination of methods depending on the situation.

The focus of this PhD thesis is an operationalisation of the concept of sustainability within transport planning. As systems thinking seems to be a relevant instrument for dealing with strategic and complex transport planning problems, the next section will explore systems thinking with a focus upon an operationalisation of the concept of sustainability.

## 2.2 Operationalisation of the concept of sustainability in transport planning

The many ways, in which the concept of sustainability can be understood, make it difficult to apply it in an unambiguous way. The concept is often used 'just' as a word or as a broad framework, the meaning of which is presupposed and not followed up on. To provide the concept with a clear meaning and to use it in a planning context, a way forward could be an attempt to operationalise the concept of sustainability. I have here presented some of the ways, in which I have identified, that the concept of sustainability can be interpreted and used. The different uses are referred to and reflected upon throughout the subsections of section 2.2.

The concept of sustainability can be regarded as 'just' a ***word*** when it is used as an adjective in relation to different tasks e.g. planning, transport etc. The concept is often used in this way without a defined meaning, or meaning whatever the user wants it to mean. The concept can also be seen as a ***mindset*** which the user applies – and thereby as something with a broader meaning than just a word, namely as a set of defined key values and norms which would be the same each time, it is applied. The mindset could be personal to the user or it could be defined and documented and possibly, if highly convincing, seen as a ***paradigm***. The concept of sustainability could also be assigned a practical approach. If such an approach is developed it could be regarded as a ***method***, or as a ***process***. The design of a sustainability method or process would require some kind of checklist which needs to be fulfilled, or a set of tools or methodologies which need to be applied. Design of a specific method or process could lead to an understanding of the concept of sustainability as an ***action***, something which is done. The concept of sustainability can also be seen as part of the ***decision***. If sustainability is operationalised through the decision making, this would need a framework describing what that means and how it is carried out. Sustainability can also be seen as a quality regarding the ***result*** of a process. If sustainability is seen as related to the outcome of a process, a set of indicators will be needed to enable a measurement of control of whether or not the results fulfil the required sustainability definition.

In this PhD thesis the concept of sustainability will mainly be seen as an action which is applied based on a mindset and suitable methods that are later on demonstrated.

### 2.2.1 The concept of sustainability

With the 'World Commission on Environment and Development', 'a global agenda for change' was requested by the General Assembly of the United Nations. The commission resulted in the publication of 'Our Common future' (UN, 1987) also known as the 'Brundtland report'. With this report the concept of sustainability was put on the global agenda. The report was based on analysis of the links between poverty, inequality and environmental degradation and on the belief that the future should be built on forceful economic growth which is social and environmentally sustainable (UN, 1987, p. 14). The concept of sustainable development was in the report defined as:

*"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (UN, 1987, p. 54).*

The Brundtland report provides the best known definition of the concept of sustainable development and its dimensions. The definition does not, however, propose to operationalise the concept. The broadness of the wording and the lack of concrete guidance on how to explicate the use of the concept can be one of the reasons why the concept has been interpreted and used in many ways depending on the application. To some transport planners the width of the definition of the concept has reduced it to a ***word***, or merely a term, which is nice to say but difficult to use, implement, and measure the result of. To others the width of the concept has led to characterising it as a ***mindset*** or even a ***paradigm***. This is consistent with the report's statements of not providing a 'blueprint for action' but a 'pathway' (UN, 1987, p.18). If the definitions of and findings about sustainable development set forward in the Brundtland report are interpreted in this way, they form a 'path'. The path leads to a desired end for which 'path followers' must develop the necessary tools and methodologies needed to form the processes and design the actions to obtain results and make decisions.

The report furthermore states what a sustainable development requires, and that these requirements should be seen as goals, on which national and international development should be built. What matters is the sincerity with which the goals are pursued and how well they are retained as a way of acting, (UN, 1987, p. 74, with underlining added):

*"(…) the pursuit of sustainable development requires:*

- *a political system that secures effective citizen participation in decision making,*
- *an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis,*
- *a social system that provides for solutions for the tensions arising from disharmonious development,*

- *a production system that respects the obligation to preserve the ecological base for development,*
- *a technological system that can search continuously for new solutions,*
- *an international system that fosters sustainable patterns of trade and finance, and*
- *an administrative system that is flexible and has the capacity for self-correction."*

In the above quote concerning the requirements for sustainable development, some main issues have been underlined as being essential for the development within this study of 'sustainable transport planning'. Specifically, this indicates the main dimensions of the concept of sustainability to be pursued. It can furthermore be noted that the systems notion as introduced earlier is used in every requirement. Figure 3 illustrates as a point of departure for the following work the concept of sustainability as based on the three dimensions i.e. social, economic and environmental. Therefore it will be necessary to take into consideration social, economic, and environmental sustainability.

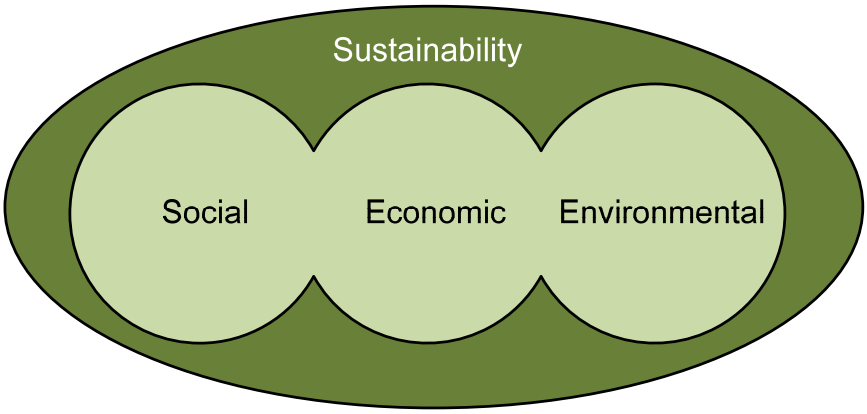


**Figure 3 The three dimensions of the concept of sustainability**

In the Chairman's foreword to 'Our Common Future' Gro Harlem Brundtland writes that when the terms of reference for the commission[3] were defined there was a proposal for limiting the considerations to 'environmental issues', and she concludes that this would have been a 'grave mistake' as the environmental issues are just one part of a greater whole, (UN, 1987, p. 13).

My understanding and use of the three dimensions of sustainability in this PhD thesis relates to both the values associated with the concept, the perspective which is used for implementation, and the level of operationalisation, which is aimed at. The three dimensions all influence whether the concept should be seen as a word, a mindset, a paradigm, a method, a

[3] Which many people today simply refer to as the Brundtland Commission

process, an action, a decision or a result. Transforming the concept of sustainability from merely a word into a personal mindset or a more formalised paradigm depends on the worldview of the user and whether or not the concept of sustainability is seen as implicit (in what could be found within traditional planning) or if it is explicated. Implicit use of the concept of sustainability often only relates to the environmental dimension, whereas an explication of the concept facilitates the use of all three dimensions. The application and explication of the three dimensions of the concept of sustainability can, however, add to the complexity of the problem situations to which the concept is applied. Therefore systems thinking is applied to examine how the concept of sustainability may be operationalised.

### 2.2.2 Sustainability and systems thinking

The Brundtland report presents an approach where all the elements of the problem situation are interconnected and where one problem (or problem element) can be a symptom or a cause of another. The Brundtland report hereby adopts a systems approach to dealing with the concept of sustainability. The concept of sustainability has later on been examined by several authors using systems thinking, see among others (Midgley & Reynolds, 2004), (Martin, 2005), and (Espinosa et al., 2008). They have done this in different ways. Below some of their findings will be discussed with the purpose of applying them here to examine how sustainability can be operationalised in transport planning.

Martin (2005) has worked with a systems thinking approach to aid practitioners who work with sustainability. He describes the use of different systems tools to explore relationships and boundaries between systems of interest. He deals with the notions of sustainability and sustainable development, which he explains as follows:

"*Whilst these terms are often used interchangeably, they mean different things. In simple terms, sustainability means the capacity for continuance into long-term future. Sustainable development is the journey or means of achieving the goal of sustainability. In systems thinking, both represent separate but connected systems of interest. To an individual or an organisation sustainable development represents a 'sphere' of influence and action over which they have some control and direction, whereas sustainability represents a 'sphere' of concern, over which an individual or organisation only exerts some limited impact directly through their sphere of influence. Identifying a professional's sphere(s) of influence facilitates a much more focused and productive dialogue on achievable actions and outcomes*" (Martin, 2005, p. 167).

This use of systems thinking enables Martin (2005) to separate the two important concepts (sustainable development and sustainability) which are often used indiscriminately. At the end of his paper he concludes that:

"*Few can argue with the goals of sustainability, but many should contest and explore how sustainability can be achieved. Hence, it is critical that environmental programmes accommodate approaches to dialogue, systems thinking and practice, principles of sustainability, values and ethics in a professional and personal context and above all they should emphasise the importance of achieving systemic change.*" (Martin, 2005, p. 170).

Martin (2005) here states that there is a difference in the goal and the journey towards the goal. The Brundtland report regards the journey towards the goal. The problem often is that the goal, here resembled by obtaining 'sustainability', is unknown. It furthermore points towards the need for defining the sphere of influence, the systems boundaries, the facts, the norms, and the values of the planner and the planning environment. The second quote of Martin (2005) indicates that to reach the goal, the goal itself needs to be explored, using dialogue and systems thinking. These quotes are seen as important for this PhD thesis's exploration of the concept of sustainability in relation to transport planning. They argue for clarifying how the concept is used for the process or the result, and that systems thinking and a systems approach are relevant for the operationalisation of the concept of sustainability.

Midgley & Reynolds (2004) have worked with the relations between operational research (OR) and environmental planning for sustainable development. Based on a study to create an agenda for the future role of OR in environmental planning and management, they found that there are three shared traditions between OR and environmental planning for sustainable development: wide boundaries, interdisciplinarity, and implementation/design (Midgley & Reynolds, 2004, p. 59). They furthermore found three complementary generic issues: complexity and uncertainty, multiple and conflicting values, and political values (Midgley & Reynolds, 2004, p. 59). Furthermore, they state that OR can become of central relevance for environmental planning for sustainable development, with regard to the social, economic, and environmental dimensions of sustainability. Boundary critique found within the critical systems thinking (CST), empowerment of stakeholders and methodological pluralism were referred to as important parts of defining an approach to design a new agenda (Midgley & Reynolds, 2004). Among the methodologies applied in the paper were Critical Systems Heuristics (CSH) and Soft Systems Methodology (SSM), see section 2.3.1 and 2.3.3 for a description of these two methodologies. Midgley & Reynolds (2004) point out that OR methods often involve quantitative methods and that not everything can be quantified, but that quantitative methods if used with care can add to the debate and to the learning about the

given subject. The study resulted in three agendas: to develop OR, to promote interaction, and to promote public participation.

The three shared traditions and the complementary generic issues identified by Midgley & Reynolds (2004) are important for this PhD thesis as they indicate that environmental planning for sustainable development is a complex task facing uncertainty, norms and values, while it operates in a political environment. The same is found in many OR applications. Based on Midgley & Reynolds' findings it is seen that methods such as SSM and CSH are applicable in complex matters of sustainable development and that the shared traditions and generic issues are relevant within transport planning. This is also relevant as this PhD thesis aims to operationalise the concept of sustainability within transport planning through a systems approach drawing on hard, soft, critical, and creative methods.

Espinosa et al. (2008) also recognise that a systems approach applied to the concept of sustainability can be relevant:

*"In general, the systems community has made several contributions to complex societal problems, including sustainability. ... Most ... approaches see sustainability as a future state to be aimed at, or to be built up in a participative way by including multiple and even conflicting viewpoints, a way to change our worldviews by creating a future of a sustainable society."* (Espinosa et al., 2008, p. 638).

Furthermore they state:

*"Sustainability requires a balanced, long-term relationship between actors and their environment. It involves a broader awareness of the need to accommodate the various interests of diverse parties in a way that maximises the interests of each through the co-existence of all."* (Espinosa et al., 2008, p. 649).

The focus of these two quotes are important for this PhD thesis, as it highlights that the goal of sustainability is reached by a long-term approach based on a participative approach including stakeholders with many (and also conflicting) worldviews. This is regarded as important input for exploring what sustainable transport planning is when it is based on a multi-methodology approach to decision making. The presented quotes and reflections can be supported by Khisty (1997) who in an editorial for a special issue on "Citizen involvement in Transport Planning" states that citizen involvement is important in all sectors, as it can help to bring the planning process to a higher level as well as help to promote sustainable development. The higher level

is reached by communication and an exchange of ideas among citizens, planners and decision makers, as well as by emancipation of the citizens.

A practical approach for using systems thinking in relation to the concept of sustainability can be found in The Natural Step (TNS). TNS is an international charity working with a systems approach to sustainable development. They focus on the earth as a system and provide a framework for companies and communities etc. to be used for strategic planning and decision making. TNS provides an analytical approach to incorporate the concept of sustainability into business strategies, policies etc. The approach is named the ABCD approach and consists of four tasks: Awareness, Baseline mapping, Creating a vision, and Down to action. The process focuses on creation of visions and back casting from these into obtainable goals, see (FoF, 2008). In section 2.3 tasks similar to those of the ABCD approach can be found in the proposed methodologies for operationalising the concept of sustainability in transport planning. The TNS framework has been applied and reported in several studies, see among others (Robért et al., 2002) and (Tippett, 2005).

Based on the examples above of how the concept of sustainability has been related to systems thinking, this thesis will follow a similar approach for an operationalisation of the concept of sustainability within transport planning. Consequently, the focus will be on systems based methodologies, multi-methodology and participation of stakeholders, see section 2.3.

### 2.2.3 Sustainability and transport planning

Transport planning and the concept of sustainability have both as concerns their treatment been related to systems. Midgley & Reynolds (2004) have shown that there are similarities between OR and sustainable development as they are both affected by uncertainty and complexity. In this PhD thesis hard, soft, critical, and creative methodologies are applied to transport planning and decision making which relates to issues about sustainability and complexity. In some respects sustainability adds to the complexity level of a given problem situation as new aspects and worldviews impact on the problem situation. Sustainability considerations are therefore integrated in the actual transport planning and its deliberations instead of being just a "green attribute" of a resulting planning document. This highlights how the concept is interpreted and understood by stakeholders such as citizens, Non Government Organisations (NGO's), professionals and decision makers who all might associate something very different within their interpretation of the term.

When the concept of sustainability is based on the definitions of the Brundtland report (UN, 1987) it can either be seen as a word, a mindset or a paradigm, depending on how the concept

is understood and used. When the concept is applied based on the three defined dimensions (social, economic and environmental) and follows the paths provided by the Brundtland report, the concept can be seen as a paradigm, but if only one dimension is applied it tends to be merely a word. When specific interpretations of the provided path and the dimensions are performed in relation to the sector of application, it can be seen as a mindset. Common for all three approaches is that they are based on an implicit use of the concept. A path is laid out and no one is given the task of ensuring that the sustainability issues are brought forward – they are expected to be considered due to the chosen path and following procedures.

Tippett (2005) applies a systems based approach to the use of the concept of sustainability using a participatory approach. In the described case focus is set upon the process of design and communication, the different scales of planning are considered and sustainability is referred to as being used both in an implicit and in an explicit way. She makes the following point:

*"Many participatory processes aim towards a socially and ecologically sustainable outcome in general terms, without necessarily having an implicit focus on sustainability."* (Tippett, 121).

I, too, find that it is important to define if the concept of sustainability is used in either an implicit or an explicit way. My perceptions of implicit and explicit to be used in the following are given below:

- **Implicit** use of the concept of sustainability often states that sustainability is needed and the term is used for all sorts of things such as planning documents, policies, etc., though it is seldom described how the concept is interpreted, applied, operationalised, controlled, or evaluated. The implicit use often relies on existing procedures to deal with sustainability issues, and does not define how it is thought to be used and how it is ensured, what comes out of it. In traditional planning a series of documents are made about the impact on the environment, and levels to measure against are set, but how these are integrated with the rest of the system and who 'speaks up for' sustainability is not defined. There are public hearings and opportunities for stakeholders to step forward but no defined process to ensure that they do so – and the use of the concept thereby relies on the capabilities such as knowledge and time of the stakeholders and officials. Methods for implicit use of the concept of sustainability are treated later on in section 3.1, 3.2, and 3.5.

- **Explicit** use of the concept of sustainability clarifies how the concept of sustainability is interpreted, applied, operationalised, controlled, and evaluated. This is achieved by developing transparent and well-described procedures which can bring the concept into action in the planning process and make sure that sustainability considerations are highlighted. Explicit use of the concept of sustainability is treated later on in section 3.3, 3.4, and 3.5, paper 3, see section 4.6 and 4.7, paper 4, see section 4.8 and 4.9, and paper 5, see section 4.10 and 4.11.

To shed light on whether the concept of sustainability is applied in an implicit or an explicit way, several issues can be considered, which concern clarification of what the concept means and what it is used for. Another important feature is determination of whether the concept is applied to the *process or result* or to both, because this will have an impact on how the concept is defined, applied and used, and what the end goal might be. Tippett (2005) brings some focus to the 'process' but does not distinguish clearly between whether the concept of sustainability is applied to the process or the results. Goldman & Gorham (2006) describe a similar approach to sustainable policy making, presenting both a 'pathway' and an 'end-state' oriented approach which can be related to either 'process' or 'result' considerations.

This PhD thesis finds that it is important to separate these two approaches. As already stated both the social, economic, and environmental dimensions of sustainability are taken into account, when this PhD thesis aims at operationalising the concept of sustainability by looking at the 'process' and the 'results', respectively. In this PhD thesis 'process' and 'results' are perceived as follows:

- **Process**: When the concept of sustainability is related to the process, the three dimensions of the concept can be seen in regard to the way the planning and decision making are conducted, and at what level stakeholders are identified and involved. Sustainability in the process concerns the actual transport planning process, and in which order tasks are conducted and evaluated to inform decision making. Who is involved, and who is affected, and what is considered and how, e.g. how alternatives and evaluation criteria are defined and selected. The process is set to be both qualitative and quantitative, as measures can be set up, but indicators are not the main issue. A process can be sustainable without the result being sustainable as well.

  With the concept of sustainability related to the process, the social dimension can be seen as regarding stakeholder participation and the possibility for all parties involved and affected to state their opinion in the process. The economic dimension of the concept can be seen as setting focus on the necessity of having alternatives to choose

between involving monetary and non-monetary issues. The environmental dimension clearly points towards considering non-monetary issues in the evaluation. Later on, the specific methodology used and developed for this thesis will be presented and discussed.

- **Results**: If the concept of sustainability is operationalised in regard to the results of a planning and/or decision making process, the three dimensions of the concept can be related to predefined indicators. Sustainability in the result concerns the outcome of the transport planning process, the actual results. These can be quantified, measured and evaluated to some defined standards or max/min levels. Evaluating a sustainable result requires a set of pre-defined indicators. A result can be sustainable both with and without a sustainable process, but a sustainable process will provide a better base for a sustainable result.

  Social sustainability can be seen as regarding diversity and living conditions. Economic sustainability can be seen as regarding feasibility and 'bottom-line' concerns. Environmental sustainability can be seen as regarding technical solutions/technology, impacts, self-sustaining systems and $CO_2$ neutrality etc.

One of many examples of 'sustainability-with-regard-to-the-result' is the 'sustainability tool' recently implemented by the Copenhagen Municipality (KK, 2009). This tool can be used to evaluate different alternative planning solutions before they are applied. The tool evaluates on a set of predefined criteria which relate to the tree dimensions. Such initiatives indicate that there is a need to know more precisely what sustainability is, where it might be applicable and how to interpret it. This corresponds to one of the main themes of this thesis, namely understanding how transport planning can be combined with sustainability and how the related complexity can be dealt with. As focus here is on the 'process', identification and use of indicators are not treated.

The final consideration that needs to be made is concerning the use of the concept with regard to either *short term* or *long term* planning, which will affect theory, methods and techniques. Short term consideration might be as short as 1-5 years, depending on the boundary condition and decision environment, however, an influencing factor is often the political terms. Long term considerations can lead to very different interpretations depending on worldview and perspective. Banister (2003, 2008) clearly sees a conflict between short and long term perspectives for strategies in relation to implementation of transport policies.

The European Commission (EC) describes in the recent publication 'A sustainable future for transport' the transport systems as complex and focuses on long-term visions and policies in order to obtain sustainable mobility. The areas of concern regard all three dimensions of the concept of sustainability and relate to both goals, planning, and prioritising procedures, emphasising that wider economic benefits should be included. This includes an extended stakeholder involvement and information to citizens so that they can obtain a better understanding of the policies and the decisions made, (EC, 2009). In regard to this thesis, the main statements are:

*"New infrastructure should be planned and prioritised with a view to maximising socioeconomic benefits, taking into account externalities and effects on the total network."* (EC, 2009, p. 17), and

*"Greater public involvement in transport planning can be ensured by recourse to participatory instruments, namely open consultations, surveys and stakeholders' representation in decision processes."* (EC, 2009, p.24).

These statements will be considered in the choice of methodology aiming at making the concept of sustainability operational in the transport planning process. EC (2009) also considers the areas of policy making and sustainable mobility, which are both relevant for sustainable transport planning. Banister (2008) can be consulted for further description of a sustainable mobility paradigm and Goldman & Gorham (2006) give a description of some of the issues regarding transport and sustainability policies, both independent areas of concern, which are outside the bound of this thesis.

## 2.3 Main methodologies in this PhD thesis

When working with an operationalisation of the concept of sustainability within transport planning several methodologies appear appropriate, see Table 5, where some methodologies are listed alphabetically with main characteristics, see (Checkland, 1993/1999), (Checkland & Poulter, 2006), (Ulrich, 1983, 2000, 2005), (Jackson, 2000, 2003), (Vidal, 2003, 2006), (Phillips, 2006, 2009).

Other methodologies might have been relevant but these have been selected based on literature reviews of their previous use in studies with scopes similar to the operationalisation of the concept of sustainability treated in this PhD thesis.

| Methodology | Characteristics |
|---|---|
| Critical Systems Heuristics (CSH) | • The present situation and the desired situation<br>• Debate regarding boundary conditions<br>• Stakeholder identification – focus on the affected stakeholders<br>• Emancipating |
| Decision Conference (DC) | • Structured debate<br>• Stakeholder participation<br>• Use of IT<br>• Group processes<br>• Decision analysis |
| Futures Workshop (FW) | • Identification of problems<br>• Generation of ideas/solutions<br>• Brings different stakeholder types together<br>• Unity among stakeholders with the same problem situation across stakeholder types |
| Soft Systems Methodology (SSM) | • Problem situation analysis and understanding<br>• Analysis of stakeholder roles and relations<br>• Analysis of social and political relations and influences |
| Vision Conference (VC) | • Establishing a common vision<br>• Stakeholder participation<br>• Group dynamics<br>• Communication across stakeholder groups |

**Table 5 Overview of considered methodologies**

Thus Table 5 can be considered as a kind of 'long-list' for dealing with the operationalisation of the concept of sustainability. Implementation of all the methodologies provided in the long-list for operationalisation of the concept of sustainability would be a demanding process. Therefore three of the identified methods have been selected for this PhD thesis, based on their previous applications and demonstrated qualities. Based on my attendance at Lugano Summer School of Systems Design 2008[4] the methodologies and methods chosen are: Critical Systems Heuristics (CSH), Decision conferences (DC), and Soft Systems Methodology (SSM). CSH and SSM turned out to have the qualities necessary for exploring an operationalisation of the concept of sustainability and at the same time they seemed to have elements that in combination could turn out to be relevant in this PhD thesis study context. DC is relevant to this PhD thesis due to the linkage of the operationalisation of the concept of sustainability to quantitative methodologies which will be described further later on. CSH, DC and SSM were chosen as each of these methods could provide elements considered important for a

[4] Lugano Summer School of Systems Design 2008, Doctoral and Postdoctoral Summer School on Soft and Critical Systems Thinking (LSS2008), University of Lugano, 2-13 June 2008, held by Werner Ulrich and Peter Checkland

sustainable planning process. Some previous and highly relevant applications are mentioned below:

- Khisty & Leleur (1997) discuss the 'traditional' rational planning method (RPM) used in transport planning with focus on its possibilities and limitations. They focus on the different types of uncertainty, which can be found in a transport planning problem (these can be related to the previously described three kinds of complexity presented by (Leleur, 2008)). The uncertainty and the limitations are due to a change from certain to uncertain means and ends in transport planning. Khisty & Leleur (1997) furthermore discuss the need for communication based planning, value judgments, power relations and methodologies such as SSM in transport planning. They examine the importance of understanding different stakeholder groups, their worldviews and emancipation. The necessity of understanding norms, values and power is considered as well. They recommend the use of SSM to deal with human activity systems and ill structured (transport) planning problems, as such an approach is aimed at learning and not at the 'solution'. SSM could therefore be part of a communication based planning approach.

- Kane & Del Mistro (2003) discuss the transport planning approach and whether or not there is a need for change in transport planning methodology, due to the change of problem types which have occurred over the years. They describe how the hard methods are not always sufficient for the planning appraisal as it has *"(…) moved from an era of relative simplicity to one of great complexity"* (Kane & Del Mistro, 2003, p. 118). This is, among others, due to the recognition of the influence of the value systems owned by all the participants in the assessment process. Every person possesses different values and norms, and these might lead them to different decisions, hence there is often no single 'best' solution. This leads Kane & Del Mistro (2003) to state that some transport planning problems require a soft approach and soft systems thinking, as this among other can help to explore the complexity of the problem situation and *"(…) the mental models of individuals involved in transport planning"* (Kane & Del Mistro, 2003, p. 120). Like Khisty & Leleur (1997) Kane & Del Mistro (2003) recognise that SSM could be valuable in transport planning. They state that SSM should not replace the traditional hard approach but serve as an addition dealing with the social and political aspects of problem situations, and that it would be a valuable methodology to add to the transport planners' toolbox.

- Khisty (2000) argues in favor of citizen participation in transport planning, as it holds the possibility for enriching the planning process and outcome for all stakeholders. He picks up on the limitations of the RPM, and its lack of participation and describes a

series of 'early' methodologies used in order to obtain citizen participation. Furthermore, he describes different participant types and their role in a participative process and deals with the importance of 'power' in relation to a participatory process, and thereby the level of influence which the participants have. He focuses on the potential of 'learning citizens groups', and their ability to set goals for themselves, to communicate and interact. CST is seen as a way forward, as it clears the way for critical reflection on assumptions, consideration of emancipation and power, and methodological pluralism (in this thesis referred to as multi-methodology). CSH is mentioned as a *"(…) checklist of twelve essential questions (…)"* (Khisty, 2000, p. 135) which can be used for public participation and which holds ability to reveal the normative content of the given problem situation.

- Phillips & Bana e Costa (2005) show how decision conferencing can be used for participative decision analysis, and how Multi Criteria Decision Analysis (MCDA)[5] can be used as an on-the-spot modelling approach. The focus of their paper is transparent prioritisation, budgeting and resource allocation, ensuring a holistic approach to the task. This includes many stakeholders with different agendas and worldviews. They find that decision conferencing provides an opportunity for developing a shared understanding, communication and commitment. At the same time decision conferencing provides a transparent process, which can be used to communicate the results of the process and the decision made or suggested.

The two first application examples indicate the advantage of SSM and illustrate that it has been successfully applied in complex transport planning problems. The third application example deals with the need for public participation in the (transport) planning process and, and how this can be obtained. As within the first and second application examples the focus is on power relations, norms, values and worldviews illustrating that CSH can be beneficial for transport planning as it provides an overview of boundary judgments. Finally, the last application example illustrates how socio-technical modeling in the form of MCDA can be used in a combined approach with stakeholder participation. Each of the three methods is presented below.

### 2.3.1 Critical Systems Heuristics (CSH)

Critical Systems Heuristics (CSH) is developed by Werner Ulrich (Ulrich, 1983) as a framework for planners and interested and concerned citizens (ordinary people) in order to enhance critical reflection. The methodology is developed for exploring and debating the

[5] In this thesis the MCDA mentioned is equal to the MCA process used

system in question, the boundary judgements and the reference system, knowing there is no single right answer but several alternative assumptions (Ulrich, 2005). One of the main aims has been to include both the involved and the affected stakeholders in the decision making. According to Jackson (2003, p. 213) Werner Ulrich's book from 1983 is of great importance as it is the first to present a systems approach in order to avoid unfairness in society by including the affected stakeholders in the decision affecting them.

Ulrich (2005, pp. 1-2) has defined seven basic terms in relation to the understanding of CSH: Heuristics, critical approach, systems approach, boundary judgments, claims, merit, and reference system. All these terms are important to the use of CSH. Boundary judgements consist of both facts and values, and determine what is considered and what is not considered. The boundary judgements influence both claims and merits. Claims are selective suggestions which we consider relevant and valid. This stated meaningfulness and justifiability are based on the boundary judgements, where merits are pragmatic, criteria are properties of claims and are based on them being relevant and acceptable for those concerned. All these terms form the reference systems which define the context or the situation of concern. Without a clearly defined reference system, discussion might be led without a common understanding of the situation and setting. Hence stating the reference system is necessary in order to understand and communicate the situation in question (Ulrich, 2005).

CSH concerns the boundary judgements of a given planning problem and regards setting the scene, defining what is considered in the picture and what is out, sweeping in all relevant information, by unfolding claims, and ensuring not to claim too much (Ulrich, 2005, p. 11). The boundary judgments explored by CSH are dependent on the systemic triangulation found in the 'eternal triangle' containing the three interrelated matters: 'system' determined by boundary judgements, 'values' determined by evaluations, and 'facts' determined by observations, (Ulrich, 2000, p. 6). Ulrich (2005) states that:

*"All that boundary critique can achieve is to help the parties in appreciating their own boundary assumptions and those of others, so that they can then articulate their concerns in a cogent way."* (Ulrich, 2005, p. 4).

Boundary critique is important when dealing with problem situations and planning because it considers reflective and emancipatory practice. Reflective practice is about being self-critical towards one's own boundary judgments, and emancipatory practice regards being critical towards those who are not self-critical. Both practices are based in a systematic process of boundary critique (Ulrich, 2005). The process of boundary critique consists of five tasks, adapted from (Ulrich, 2005, p. 4):

- Identify
- Examine
- Find
- Seek
- Challenge

CSH is a practical methodology which can be used as a part of the planning process while considering the planning problem and its boundary conditions. CSH consists of twelve questions which can be asked in two modes, the 'is-mode' and the 'ought to-mode', see Table 6.

| No. | Boundary issues | | Questions |
|---|---|---|---|
| 1 | Sources of motivation | Those involved | Who 'is' ('ought to be') the **client** or beneficiary? |
| 2 | | | What 'is' ('ought to be') the **purpose**? |
| 3 | | | What 'is' ('ought to be') the **measure of improvement** or measure of success? |
| 4 | Sources of power | | Who 'is' ('ought to be') the **decision-maker**? |
| 5 | | | What **resources** and other conditions of success 'are' ('ought to be') controlled by the decision-maker? |
| 6 | | | What conditions of success 'are' ('ought to be') part of the **decision environment**? |
| 7 | Sources of knowledge | | Who 'is' ('ought to be') considered a **professional** or further **expert**? |
| 8 | | | What kind **of expertise** 'is' ('ought to be') consulted? |
| 9 | | | What or who 'is' ('ought to be') assumed to be **guarantor** of success? |
| 10 | Sources of legitimation | Those affected | Who 'is' ('ought to be') **witness** to the interests of those affected but not involved? |
| 11 | | | What secures ('ought to secure') the **emancipation** of those affected from the premises and promises of those involved? |
| 12 | | | What **worldview** 'is' ('ought to be') determining? |

**Table 6 Boundary issues and the 12 questions, adapted from (Ulrich 2005, pp. 10-11) and used in paper 2 (Jeppesen & Paucar-Caceres, 2008).**

The 'is-mode' explains the problem situation as it is and the 'ought to-mode' describes the ideal situation or the situation as it ought to be based on the worldview of the respondent to the questions. Within the twelve questions there are four relevant sources: sources of motivation, power, knowledge, and legitimation. The first three sources regard the involved stakeholders and the last one the affected stakeholders, and all sources are part of the reference system

(Ulrich, 2005). The questions need not be asked in the numerical order but can be addressed in the order found most suitable. Werner Ulrich has later suggested another application approach of the CSH questions. Based on input from Martin Reynolds the following order was proposed. The numbers refer to the question number: 2-1-3, 5-4-6, 8-7-9, and 11-10-12 (Ulrich, 2008). By this approach the stakes/major concerns, then the stakeholders/social roles and finally the issues at stake/the crucial conflicts are addressed for each of the sources (Ulrich, 2000).

CSH can, according to (Ulrich, 2000) and (Jackson, 2000, 2003), be placed within the emancipatory paradigm, where it helps to enlighten and empower both involved and affected stakeholders. Jackson (2003) states that CSH both can be used on the outcome of hard and soft systems thinking in order to define who are affected both as beneficiary and victims. There are as well some criticisms regarding CSH, a few of these are mentioned here. Luckett (2006) finds that CSH might not be robust enough to deal with the misrepresentation in communication which can occur when power relations are unequal. She mentions as well that it is not clear how CSH enables the affected to communicate with the involved. Midgley (1997) comments that CSH is not a replacement of other systems approaches but should be seen as complementary to them.

The 'ought-to-mode' of CSH can be helpful within transport planning as it can help to identify relevant stakeholders, who might have been overlooked by a traditional planning approach. The differences between the 'is- and the 'ought to' mode highlight this in an easy, applicable way. Furthermore, CSH sheds light on boundary judgements and considerations. Based on this information relevant stakeholders can be invited to participate in the transport planning. Specifically, CSH was chosen based on its ability to shed light on how the situation 'ought to' be and its direct relevance to planning. Still there might be a need to combine CSH with other methodologies in order to obtain an approach which could incorporate the three dimensions of the concept of sustainability into transport planning, particularly on the tasks following the task of stakeholder and boundary identification.

### 2.3.2 Decision Conference (DC)

The methodology known as Decision Conference (DC) was developed by Cameron Peterson at Decision and Designs Incorporated in the late 70s/1980 (Goodwin & Wright, 2004) and (Phillips, 2009). DCs are a tool to organise and structure debates about complex problem situations involving several stakeholders. The main idea is to bring more stakeholders into the decision process than was the case at the time of development and to enable a structured debate to enrich the basis on which decisions were made (Phillips & Bana e Costa, 2005). The

goal of the debates is not necessarily to obtain consensus, but to accomplish acceptable and liveable solutions for all participants as well as conducting a common understanding and a group commitment (Phillips, 2009).

A DC consists of three main elements: group processes, IT, and decision analysis (Goodwin & Wright, 2004, p. 323) and has three important factors: involvement of key stakeholders, no formal programme, and no underlying presentation. Decision support techniques are introduced as on-the-spot modelling and used along the process, with an emphasis on the participants understanding every step, so no black-box process/solutions will occur (Phillips & Bana e Costa, 2005). The decision analysis techniques, which are introduced, are explained along the conference and based on these, a decision model capable of handling the issues in question is built through the process. Phillips & Bana e Costa (2005) point out that focus should be on the social group processes rather than on development of state-of-the-art decision model/IT techniques that might seem black-box-like to the participants.

The duration of a DC is (depending of the nature of the subject) set to be 2-3 days and should be held in 'neutral' surroundings, often in a location away from everyday working life, so that no one has an advantage of being familiar with the setup and the surroundings (Goodwin & Wright, 2004, p. 324) and ( Phillips, 1984). The participants should be placed so they are able to see both one-another and the screens used to display the models at all times (Phillips, 2006) and (Goodwin & Wright, 2004). The set-up furthermore contains an impartial facilitator guiding the participants through the process and a decision analyst running the decision model based on the output of the conference. The facilitator should help to ensure that all stakeholders get an equal chance to share their knowledge and opinions, to steer the group through the process, and to explain all the decision techniques and model related tasks to the participants (Phillips, 2006).

A DC can have many different outlines. Phillips & Bana e Costa (2005, pp. 5-6) outline four basic steps of a DC:

- Exploration of the issues
- Structuring and building a model
- Exploring the model
- Agreeing on the way forward

Phillips & Bana e Costa (2005) and Phillips (2006) furthermore propose outlines of how to overcome these basic steps in organisation of decision conferences. A further development of decision conferences is decision conferencing. Decision conferencing consists of a series of

decision conferences, held with different stakeholders and summarised at the end by the final decision conference in the series. These decision conferences can be supported by interviews and workshops (Phillips, 2006, p. 14). These are useful if the problem situation is complex and involves many large groups of people.

DCs can be related to both the interpretive and the emancipatory paradigm as they both explore the problem situation and bring stakeholders into the decision analysis through group techniques and optional use of creative or other methods and techniques depending on the problem situation in question. Decision conferences can be considered a socio-technical approach (Phillips, 2006), which in relation to the two paradigms it draws upon is promising, as it will enhance both the knowledge and the stakeholder interaction based on different approaches combined in one methodology. However, it is the responsibility of the facilitator to ensure emancipation and/or critical reflection of the problem structuring or representativeness of the participants.

DCs have provided a framework that could be implemented in the transport planning process, as the DC outline enables a structured debate between problem owners, decision makers, experts and various groups of affected stakeholders. This is an important task which is often requested in planning situations. This would furthermore be relevant in relation to the operationalisation of the social dimension of the concept of sustainability within the transport planning process. Specifically, DCs were chosen based on their combined use of IT, group processes and decision analysis. Still there might be a need to combine DCs with other methodologies in order to operationalise the three dimensions of sustainability within transport planning. One example could be methods or techniques that help to understand the problem situation, so the DC can have the right content and target. Another complication regarding the use of DCs in transport planning is the time and the resource demand. It might be difficult to conduct a 2-3 day DC with as many as 20 participants as time is always a limited resource.

### 2.3.3 Soft Systems Methodology (SSM)

Soft Systems Methodology (SSM) was developed by Peter Checkland and his colleagues at Lancaster University during the 70s. The development of SSM was based on action research and was a reaction to the shortcomings of the existing management methodologies and their lack of abilities to deal with complex problems where human factors were involved, (Jackson, 2003).

The methodology has due to its many applications, the derived learning and continuous development undergone change and development since it was first presented, (Checkland

1993/1999), (Jackson, 2003). The first layout was a 7-step model, now known as SSM Mode 1, see Figure 4. The 7 steps of the 'classic' SSM approach consider the following seven steps: (Checkland, 1993/1999, pp. 161-183):

1. Finding out about the problem situation
2. Problem situation expressed
3. Root definitions
4. Modelling
5. Comparisons
6. Changes
7. Taking action

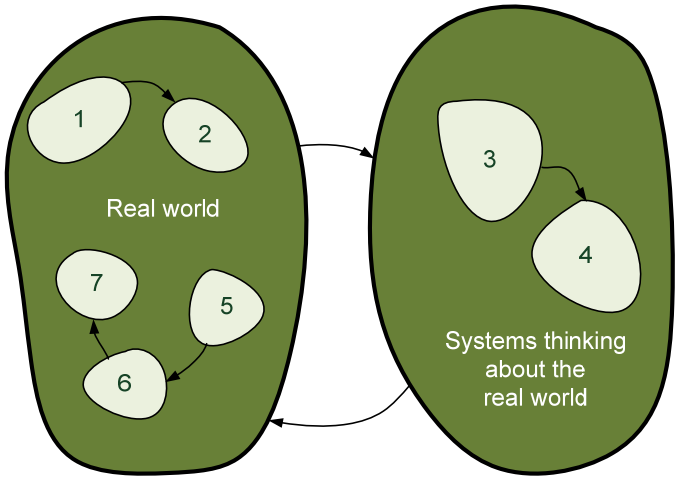


**Figure 4 Overview of the 'classic' 7-stage model of SSM known as SSM mode 1, adapted from (Checkland, 1993/1999, p. 163). The numbers refer to the steps outlined above.**

Five of the seven steps (step 1-2 and 5-7) take place in 'the real world' and the two remaining steps (step 3-4) take place in 'systems thinking about the real world'. The steps are supported by tools designed for the seven steps such as rich pictures, root definitions, CATWOE[6], conceptual models including the five E's[7] used for monitoring and control, and comparison tables, for a further description of SSM and its tools and application see among others (Checkland, 1993/1999) and (Checkland & Poulter, 2006).

The 'classic' 7 step model has been developed into a more unconstrained approach known as mode 2. Mode 2 covers the same questions and tasks as mode 1 but in a less systematic way, see Figure 5. Mode 2 consists of three types of analyses (simply named analysis 1, analysis 2, and analysis 3), which regard the system itself, the social system, and the political system in relation to the problem situation and draws upon the classical tools of rich pictures, root definitions, CATWOE, conceptual models and, comparisons, see (Checkland, 1993/1999) and (Checkland & Poulter, 2006). The more unconstrained application of SSM in mode 2 allows the methodology to be more easily internalised in the organisations and problematic situations where it is applied, (Jackson, 2003).

[6] CATWOE is an acronym for customer, actor, transformation, Weltanschauung, owner and environment
[7] The five E's stand for Efficacy, Efficiency, Effectiveness, Elegance, and Ethicality

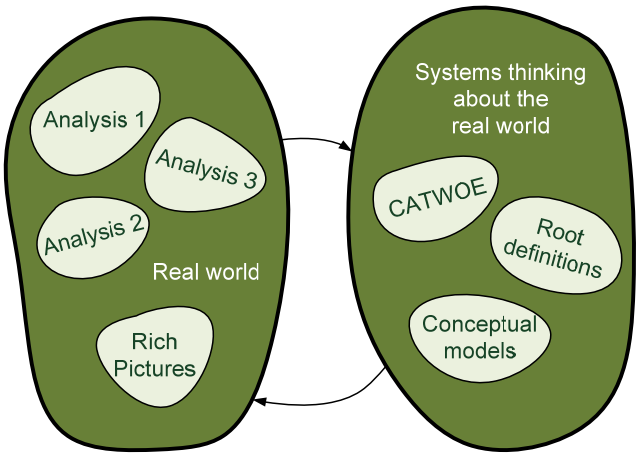


**Figure 5 Overview of SSM mode 2. The figure is based on the SSM mode 2 descriptions in (Checkland & Poulter, 2006)**

According to (Jackson, 2000, 2003) SSM can be placed within the interpretive paradigm. This means that the methodology has the capability to explore and interpret problem situations. Jackson (2003) points out that as SSM is embedded in the interpretive paradigm, systems thinkers of the functionalist, emancipatory, and post modern paradigm may find that 'something is missing'. Furthermore Jackson (2000, 2003), Basden & Wood-Harper (2006), Bergwall-Kåreborn (2006), have among others found that though SSM is a mature methodology with many successful applications, it still has its limitations both regarding tools, areas of application and philosophical underpinnings. Ormerod (2007) and Munro & Mingers (2002) have also proposed and reported that SSM could gain from joint applications with other methodologies.

The main idea of SSM is to identify the problematic situations and learn about these through cyclic learning. This leads to suggestions of purposeful actions leading to changes which should be both desirable and cultural feasible and thereby lead to action based on accommodation between stakeholders (Jackson, 2003). The 'classic' 7 step model in mode 1 and the less constrained approach known as mode 2 each have useful capabilities in relation to transport planning. More specifically, SSM was chosen in this PhD thesis based on its ability to explore problem situations and reveal roles and relations of and between stakeholders. In mode 1 the most useful steps would be steps 1-4, and in mode 2 analyses 1-3. The root definitions, CATWOE and conceptual modelling appear as the most important techniques as the traditional transport planning procedures include techniques for comparison, making change and taking action. These first steps of either mode 1 or mode 2 are considered as vital for transport planning as they would help defining the problem situation clearly. They can help to reveal if any problematic symptoms are results of non-recognised sub-problems. Furthermore, analyses 2 and 3 could provide important information about how stakeholders

might or might not act, if there are hidden power relations within non-recognised roles and relations. Still there might be a need to combine SSM with other methodologies in order to explore an operationalisation of the concept of sustainability. SSM has a great study potential to examine the concrete situation but might lack a capability to pay attention to boundary conditions and critical reflection. Its ability to deal with stakeholders when they are invited to intervene might be insufficient too, as there are no rules and specification of how this should be managed, and much therefore depends on the facilitators/consultants conducting the interventions.

# 3 A multi-methodology approach to transport planning and decision making

This chapter presents the four methodology developments produced throughout this PhD study. The four methodology developments were used as a foundation for the operationalisation of the concept of sustainability in transport planning. After each of the methodology development descriptions a SWOT matrix (Zwaenepoel, 2004) is used to summarise the potential of the proposed method.

In Chapter 1 transport planning was described as getting more and more complex. In Chapter 2 the relations between sustainability and systems thinking, complexity and transport planning were treated and sustainability was seen as yet another factor which adds to the complexity level within current transport planning. To deal with the occurring problem situations these can be described through the systems terminology. Finding out what kind of problem is ahead, the planner has to choose whether to apply a systematic or systemic approach depending on the problem being 'traditional' or 'complex'. In relation to dealing with the concept of sustainability and transport planning it was mentioned in Chapter 2 that participation by a wide range of stakeholders would be relevant. Based on the recognition of sustainability as having both a social, economic, and environmental dimension and with the purpose of exploring the operationalisation of sustainability in transport planning by setting focus upon the process, a selection of well-known methodologies has been applied and re-designed. The background for this development is the methodologies treated in Chapter 2. The development and use of these methodologies on specific cases makes up the conceptual part of this PhD thesis documented by altogether five papers, see the thesis structure in Figure 1. Four papers are presented and published, and the last one is submitted for review. Each of the four method-developments are described below.

## *3.1 Semi-Soft application of soft methods*

There is often a very tight time and/or resource constraint related to dealing with transport planning problem situations. This can have an effect on the level of stakeholder participation in the problem solving process. In order to gain some of the benefits of soft methods (soft

methods here consist of soft, critical, and creative methods) but with a minimum time and resource use Jeppesen et al. (2007, 2008) have developed the term 'semi-soft' methods, see paper 1 section 4.2 and 4.3 for (Jeppesen et al., 2008).

Semi-Soft use of soft methods refers to a way of application in which the methods and techniques are applied not by participative intervention, but by an informed analyst (at his or her desktop). The analyst is acting like a set of stakeholders by simulating the probable worldviews and preferences. Semi-Soft methods can be used to gain as much information as possible from the soft methods without direct stakeholder participation. The information is used to gain perspective of the problem situation in regard to stakeholders, roles, relations, sub-problems, alternatives, criteria etc., and is based on information gathered from the given knowledge of the problem, previous reports, and other such information sources. This can be relevant if there is lack of time and resources or as a part of a scanning process (pre-planning or before a larger study). Semi-Soft application of soft methods might also be an option in cases where only a hard approach would have been applied, and the semi-soft application of soft methods can thereby serve as an input for the hard methods. In paper 1, see section 4.2 and 4.3, the application proved to be probable and highly practical, and semi-soft input embedded in a hard approach seems to be promising but in need of further examination, see (Jeppesen et al., 2008). Some of the most important characteristics of soft and semi-soft methods are shown in Table 7. From this table a quick overview of the different uses can be gained.

| Soft methods | Semi-Soft methods |
|---|---|
| • Conducted with stakeholder participation<br>• Conducted by an intervention with varying duration and stakeholder participation<br>• Stakeholder interaction, synergies are developed and roles and relations are revealed<br>• Can be time consuming<br>• Can be difficult to involve relevant stakeholders as they sometimes are too busy to find time to participate in an intervention<br>• Can involve stakeholders representing different worldviews | • Conducted by an informed analyst<br>• Conducted at the desk top<br>• A 'fast' application type<br>• The analyst is gathering as much information as possible and simulating the stakeholders viewpoints and preferences<br>• Provide reflections based on a soft approach, when there is no possibility to conduct an intervention with stakeholder participation<br>• Might not reach full potential of the applied methods |

**Table 7 Characteristics of soft and semi-soft methods**

Even though a semi-soft application of soft methods is helpful and practical it is still preferable to have stakeholder participants whenever possible in order to use the soft methods in their 'traditional' way, because the full potential of the soft methods is not reached with the semi-soft application. A challenge of the semi-soft application is the lack of a group process and the fear of something 'being overseen' and thereby left out, lack of different worldviews, and lack of direct display, and lack of information about roles and relations, which are not accessible through indirect and printed information on a topic. Last but not least another threat is that the accessible information is not of an appropriate quality. The semi-soft application of soft methods can obviously never be better than the available information (written or obtained in any other way), see (Jeppesen et al., 2008).

To evaluate the proposed use of soft methods in a semi-soft way, the SWOT matrix below is conducted to highlight strengths and weaknesses as well as opportunities and threats, see Table 8. The statements made in the SWOT matrix can facilitate further development of the semi-soft application.

| Strengths | Weaknesses |
|---|---|
| • Fast application<br>• Gains as much as possible from the soft methods<br>• Can be used in scanning procedures<br>• Can be embedded in a hard approach | • Information might not be brought forward as it is not identified<br>• Lack of group process<br>• Lack of interaction between participants and inputs derived from such |
| **Opportunities** | **Threats** |
| • Enables some of the information from soft methods to be embedded in hard methods in an easy way<br>• Might make the soft methods more applicable for hard systems thinkers<br>• Can broaden the use of soft methods | • Never better than the accessible information<br>• Lack of understanding of worldviews, roles and relations<br>• Might be accused of lacking understanding of the soft methods use and qualities |

**Table 8 SWOT matrix of semi-soft application of soft methods developed in this thesis**

Semi-Soft application of soft methods seems to be a helpful approach when dealing with hard methods as this can provide information which otherwise would not have been accessible. During this PhD thesis semi-soft methods have been applied in the formulation of a pre-planning scanning process named Decision Simulation Technique (DST), see paper 3 sections 4.6 and 4.7 and in the sustainability exploration in paper 5 sections 4.10 and 4.11.

## 3.2 Critical Soft Systems Framework (CSSF)

In Chapter 2 Soft Systems Methodology (SSM) (Checkland, 1993/1999) and (Checkland & Poulter, 2006) and Critical Systems Heuristics (CSH) (Ulrich, 1983, 2005) were identified as relevant, beneficial and applicable for transport planning. Both methodologies could be useful in a transport planning process, either as a whole or in parts used in a multi-methodology approach. The methods are thought to be useful when dealing with complex transport planning problems, especially with regard to a combined problem structuring, and stakeholder identification and analysis, leading to models to deal with the problem situation in question. The two methodologies have several similarities and can complement each other in some areas. Jeppesen & Paucar-Caceres (2008) have proposed a combination of SSM and CSH in what is called Critical Soft Systems Framework (CSSF), see paper 2 section 4.4 and 4.5 for (Jeppesen & Paucar-Caceres, 2008). This combination provides a more profound critical reflection in the two first phases of SSM. This approach is useful when working with the methods in a semi-soft approach and within transport planning as it can help to understand and reflect upon a complex matter. The four main parts of CSSF are described below based on (Jeppesen & Paucar-Caceres, 2008):

- **Task No. 1 – Finding out about the problem situation**
  In the first step, CSH is introduced to the 'real world' and the 'is' mode of the CSH is applied to the 'finding out about the problem situation' of SSM. The CSH questions are found to be helpful in understanding the problem situation as it is. This is done by the guidance of the 12 questions which provide for the use of several worldviews and reflections upon motivation, power, knowledge and legitimating as these factors are defined in (Ulrich, 2005). It brings attention to resources, stakeholders, and worldviews alike as well as the decision environment, which is useful in relation to the rich picture tool or mode 1-3 of SSM mode 2 and as assistance to the facilitator.

- **Task No. 2 – Conceptual modelling**
  In the second step, CSH is introduced to the 'systems thinking about the real world' and the 'ought to' mode of the CSH questions is applied to the construction of root definitions and purposeful models. The CSH questions are found to be helpful in relation to introducing critical reflection regarding the problem situation and how the root definitions are formed. The 12 questions facilitate critical reflection upon one's own thinking and upon others, if they are not reflective by themselves (Ulrich, 2005). This is useful when producing the root definitions and performing the CATWOE analysis used for the purposeful modelling as it will provide a broader picture of the problem and sub-problems as well as a reflection upon different worldviews.

- **Task No. 3 – Comparison**
  In the third step, the comparisons are proposed to be conducted as in SSM with no changes made. The findings from the critical reflection in the first and second steps are expected to be applied.

- **Task No. 4 – Implementation**
  In the fourth step, the implementation is proposed to be conducted as in SSM with no changes made. The findings from the critical reflection in the first and second steps are expected to be applied.

To evaluate the use of CSSF the SWOT matrix below highlights strengths and weaknesses as well as opportunities and threats of the proposed approach, see Table 9. The statements made in the SWOT matrix can facilitate further development of the CSSF.

| Strengths | Weaknesses |
|---|---|
| • Combines methodologies from the interpretive and emancipatory paradigm<br>• Emphasises both problem-structuring, problem-solving and boundary judgements and critique<br>• Both exploring and critical at the same time | • Yet another approach<br>• Not novel but a comment on two existing methodologies<br>• No case applications (yet) |
| **Opportunities** | **Threats** |
| • Can 'emancipate' SSM, by introducing more critical reflection<br>• Provides broader perspective | • Lack of use due to the use of multi-paradigm multi-methodology<br>• Properties of the individual methodologies of SSM and CSH could be lost |

**Table 9 SWOT matrix of the developed CSSF**

The SWOT matrix in Table 9 demonstrates that a combination of SSM and CSH into CSSF can draw upon the strengths of both methodologies and thereby broaden the problem understanding and solving. A combination of the two methodologies also implies the risk that some of their individual strengths are left out and that the combination of paradigms and modification of known methods might stop some from using the CSSF.

During the work with CSSF several similarities were found between CATWOE and the twelve questions of CSH, and CSH was embedded in SSM in the CSSF. Afterwards the CSSF has been related to the work of Brigitte Bergvall-Kåreborn (2006), where a similar approach was

taken. Bergvall-Kåreborn (2006) focuses on how CSH can be used to clarify a certain worldview, how CSH relates to and compliments the CATWOE analysis, and how CATWOE can be redefined and extended by CSH. Bergvall-Kåreborn (2006) proposed how the elements of CATWOE can be explicated by a change of element names and development of the individual elements, so they are made more explicit in their content. This proposal results in a change from CATWOE to PACDAW[8] (Bergvall-Kåreborn, 2006), see Table 10.

| Existing | Bergval-Kåreborn proposal | |
|---|---|---|
| C – customer | Affected | A |
| A – actor | Actor (or "those who would carry out the activities of the process, including their specific competence(s)) | A |
| T – transformation | Process | P |
| W – weltanschauung | Weltanschauung (Worldview) | W |
| O – owner | Decision maker | D |
| E – environment | Constraint | C |

**Table 10 Overview of the change from CATWOE to PACDAW**

Bergvall-Kårebon (2006) further develops the existing CATWOE to PACDAW questions by a series of sub-questions based on CSH in order to use the boundary critique to enhance CATWOE. This can be seen in relation to Jeppesen & Paucar-Caceres' (2008) work with comparing the content of CATWOE and the CSH questions. This thesis compares the two approaches and the results of the comparison are illustrated in Table 11. Table 11 demonstrates where Bergvall-Kåreborn (2006) suggests an enhancement of CATWOE with CSH questions and where Jeppesen & Paucar-Caceres (2008) found similarities between CSH questions and CATWOE elements. Table 11 furthermore shows which questions Bergval-Kåreborn (2006) will use as sub-questions for an extended version of CATWOE in the form of PACDAW. These questions have a similarity with the ones Jeppesen & Paucar-Caceres (2008) found not to be covered by CATWOE.

The two approaches present similar but also quite different approaches to the use of SSM and CSH in combination. They both set out to enrich SSM with CSH. Bergvall-Kåreborn (2006) focuses on the use of CSH in CATWOE and the development of CATWOE into PACDAW. Bergvall-Kåreborn (2006) is based on a theoretical and philosophical approach, whereas Jeppesen & Paucar-Caceres (2008) focus on if and how CSH can be implemented in the whole of SSM as a development of the methodology into a more critical framework, called CSSF.

[8] PACDAW is the acronym of 'process, affectee, constraints, decision-maker, actor, Weltanschauung'

| | The 12 CSH questions sorted by No. | | | |
|---|---|---|---|---|
| CATWOE | Relations between CSH and CATWOE (Jeppesen & Paucar-Caceres, 2008) | Extension of CATWOE with CSH (Bergvall-Kåreborn, 2006) | Equal sorting | CATWOE extended by CSH question No. |
| Customer | 1 | 1-10-11 | 1 | 10-11 |
| Actor | 5-7-8 | 7-8-9-10 | 7-8 | 9-10 |
| Transformation | 2-3 | 2-3-5a | 2-3 | 5 |
| Weltanschauung | 12 | 12 | 12 | - |
| Owner | 4 | 4-5b-6-10-11 | 4 | 5-6-10-11 |
| Environment | 6 | - | - | - |
| No relation | 9-10-11 | - | - | - |

**Table 11 Allocation of the CSH questions (by No.) with regard to their equivalent in CATWOE, as represented by the two sets of authors.**

Jeppesen & Paucar-Caceres (2008) focus on limitations and similarities, strengths and weakness and how SSM and CSH can improve each other, whereas Bergvall-Kåreborn (2006) sets focus on the development of sub-questions from CATWOE to PACDAW based on CSH and the understanding of Weltanschauung/worldview. The similarities of the results are interesting for the further development of CSSF as the enhanced CATWOE, PACDAW, with the stated sub-questions as guidelines, could be useful in the framework and the further development of critical reflection within the problem structuring and solving process.

## *3.3 Decision Simulation Technique (DST)*

The suggested semi-soft use of 'traditional' soft methods can, as demonstrated in paper 1 section 4.2 and 4.3, be used in combination with the more mathematically based 'hard' methods applied in the COSIMA[9] decision model, see (Salling et al., 2007) and Appendix 1 for further information regarding COSIMA. Jeppesen (2009a) develops a scanning tool, named Decision Simulation Technique (DST), which can be used by planners and decision makers to obtain more planning and pre-decision making information regarding how different alternatives will perform under different strategies, see paper 3 section 4.6 and 4.7 for (Jeppesen, 2009a) and Appendix 2 for a memorandum of the case study used in this paper. The developed DST combines hard methods and soft methods, applied in a semi-soft way, and is being used to assess different alternatives for a given problem situation with regard to their

[9] COSIMA is the acronym for 'Composite model for assessment' and the name of the applied decision model

attractiveness under different strategies. The DST is conducted by a single analyst as a desktop exercise based on existing information and the use of semi-soft methods.

DST can be used to explicate a sustainability strategy to decision making in a pre-decision making scanning process, see paper 3 in section 4.6 and 4.7. The three dimensions of the concept of sustainability are explicated through the use of DST. The environmental sustainability is 'explicated' through the choice of criteria under which the alternatives are evaluated. The economic sustainability is explicated through the use of cost-benefit analysis (CBA). The social sustainability is explicated through the representation of several stakeholders and their direct or indirect influence on the assessment result. The developed DST consists of three modules: the decision problem, the stakeholder analysis, and the preference analysis, see (Jeppesen, 2009a):

- **Module No. 1 – Decision Problem**
  The first module concerns the decision problem, its properties and understanding. The problem situation is mainly based on the use of the rich picture tool by (Checkland, 1993/1999). Information about the alternatives in question and the criteria for assessment are, if defined beforehand, fed into the rich picture along with all other available information regarding the problem situation and its properties. If the alternatives and the criteria are not defined prior to the analysis, these should be defined before the conduct of the rich picture where the available information is structured. The module resembles an interrelated loop-like learning process where information is fed between alternatives, criteria, and the rich picture.

- **Module No. 2 – Stakeholder analysis**
  The second module concerns the stakeholder analysis and is based on CSH (Ulrich, 1983, 2005) and brainstorming. An application of the 12 questions of CSH in both the 'is' and the 'ought to' mode helps clarifying if any relevant stakeholders have not been identified. The use of CSH is supported by the use of brainstorms, which feed more information into the CSH based on the information gained from module 1.

- **Module No. 3 – Preference analysis**
  The third module concerns the preference analysis and is based on the COSIMA decision model (Salling et al., 2007) and the defined strategy. In this module, definition of the strategy, which will be simulated in the decision model, is the most important. The applied strategy is defined based on a set of pre-defined key-values and conducted to serve a certain worldview, which is represented by an 'advocate' for the strategy in the decision model.

In paper 3, (Jeppesen, 2009a), the concept of sustainability is explicated by a sustainability advocate. The role of the sustainability advocate is to simulate the worldview of sustainability concerns.

Below, a SWOT matrix for the developed DST is conducted, see Table 12. The analysis is based on the experience gained from the case study, see (Jeppesen, 2009a) and the feed-back gained when it was presented at the ISSS conference 2009. The SWOT matrix indicates strengths and opportunities as well as weaknesses and threats, which can facilitate future applications of the DST.

| Strengths | Weaknesses |
|---|---|
| • Introduces a strategy 'advocate', in this case a 'sustainability advocate'<br>• Introduces a pre-planning scanning<br>• Can reduce the number of alternatives at an early stage<br>• Can help to reduce the use of resources in the final planning and assessment phase<br>• Provides broad information<br>• Can be used to specify one or more worldviews<br>• Easy to test more worldviews when data for the first one has been implemented in the decision model.<br>• Has been tested on a real case study | • Definition of the strategy – e.g. the sustainability strategy, as there in this description is used a set of key values, but not a formal methodology<br>• It is a simulation, and therefore an approximation<br>• Has not yet been tried in a 'real' planning situation<br>• Requires a vast amount of input information (normally only attainable for larger infrastructure projects)<br>• Requires an analyst with full understanding of the underlying decision model and the processes of the simulation technique |
| **Opportunities** | **Threats** |
| • Possible to gain valuable information before the planning process begins<br>• Can investigate different strategies with little time use<br>• Can develop the technique by methods to define the strategies<br>• Could with small changes be applicable for a municipality or government level on both small and large scale projects<br>• Work on semi-soft input | • The strategy is not clear enough<br>• The strategy is not suiting<br>• Cannot cover everything<br>• Not a 'final' knowledge<br>• Must not be taken as the 'final truth' as it is a simulation<br>• A strategy can never be 'stronger' or more specific than the proposed criteria, which can be either predefined or defined for the purpose |

**Table 12 SWOT matrix of the DST developed in this PhD thesis**

As illustrated in (Jeppesen, 2009a), the developed DST is demonstrated to have a promising potential in order to help explicate sustainability (or other) strategies in transport planning,

especially at the early stages. There is a number of strengths, which can be developed further building on the opportunities, especially regarding the use of an explicit strategy presented by the 'advocate' throughout the whole assessment.

## 3.4 Short Decision Conferences (SDC)

When decisions are to be made and direct stakeholder participation is sought, a Short Decision Conference (SDC) can be of use. SDCs are a further development of 'traditional' DCs as presented by (Phillips, 2006) and (Phillips & Bana e Costa, 2005). They have a potential for implementation in the transport planning and decision making processes as their format is designed to suit this setting. Jeppesen (2009b), paper 4, has classified four DC types of which two can be regarded as 'traditional' and two as new types developed to fit the constraints often found within transport planning, see paper 4 section 4.8 and 4.9 and memorandums of the associated case studies in Appendix 2 and 3.

The new DC types (the two SDCs) proposed in this thesis for transport planning have in their generic form seven steps. These steps should for each SDC be designed to fit the decision problem in the best possible way. First the facilitator(s) and decision analyst(s) are presented, then a short presentation of the programme of the SDC is given, and afterwards the 'rules' and expectations of participants are addressed. The seven generic steps are:

- Step No. 1 - Presentation of decision problem
- Step No. 2 - Presentation of alternatives
- Step No. 3 - Definition of criteria and prioritising
- Step No. 4 – Pairwise comparisons of all alternatives under all criteria
- Step No. 5 - Definition of importance level of CBA versus MCA
- Step No. 6 - Discussion of results
- Step No. 7 - Evaluation of the process

Below the main contents of the SDCs have been described to outline their structure as applied on the cases described in paper 4. It can be noted that the SDCs use the COSIMA decision model, which is described in Appendix 1. COSIMA is based on a composite use of a cost-benefit analysis (CBA) and a multi-criteria analysis (MCA).

**Step No. 1 - Presentation of decision problem**

The decision problem must be specifically defined before the SDC starts and any special interest stated so it can be considered in the planning of the SDC. The decision problem in question will be defined through preliminary meetings with the problem owner or at preliminary workshops. Main themes of a SDC might be definition of criteria, pairwise comparisons of all alternatives under each criterion, definition of the trade off between the cost-benefit analysis (CBA) and the multi-criteria analysis (MCA).

**Step No. 2 - Presentation of alternatives**

After the presentation of the decision problem and its focus, the defined alternatives will be presented, in short, but still so thoroughly that every participant is well acquainted with the alternatives and their specification. The alternatives will be based on the existing information (reports, assessments, calculations), if they are not fulfilling further alternatives can be defined prior to the SDC through meetings with the problem owner or at preliminary workshops.

**Step No. 3 - Definition of criteria and prioritising**

The criteria used for the evaluation can be either designed beforehand by the decision makers or designed as part of the process. If the criteria are designed and evaluated beforehand e.g. through an Environmental Impact Assessment (EIA) a SDC can be used to verify, whether the involved stakeholders agree with the EIA. If a set of criteria has been defined beforehand, but the decision makers are not sure whether they cover all aspects sufficiently or are adequately defined, a session can be conducted to discuss the existing criteria and the possibility of defining new ones. When the criteria are defined the participants are asked to prioritise them according to their importance for the decision problem, with the most important criterion as No. 1, the second most important as No. 2, etc.

**Step No. 4 – Pairwise comparisons of all alternatives under all criteria**

After the criteria have been clearly defined and prioritised they are used for the pairwise comparisons. In the fourth step all the alternatives are compared two by two towards all criteria. The participants discuss how the alternatives perform towards the criteria and a verbal evaluation is agreed on by the participants.

**Step No. 5 - Definition of importance level of CBA versus MCA**

In this step the participants are introduced to the concept called the MCA-% which describes the relative importance of MCA vs. CBA. A high MCA-% indicates a high influence from the MCA on the combined analysis. The result is a combined attractiveness measure called the Total Rate of Return (TRR), see Appendix 1.

**Step No. 6 - Discussion of results**

The outcome of the group discussions of the previous tasks have all been entered into the decision model by the decision analyst, and on-the-spot modelling is conducted. The results are presented as a graph where the attractiveness of each of the alternatives is shown. The results, the robustness, and the sensitivity are then discussed with the participants.

**Step No. 7 - Evaluation of the process**

The last step for the participants is to evaluate the process of the day. This is done first by filling in an evaluation chart – and determined by the available time this will be followed up by a 'round-table' discussion.

Based on the two applications described in (Jeppesen, 2009b) see paper 4 section 4.8 and 4.9 and Appendix 2 and 3, this thesis recommends that a SDC is set to last one day – approximately 8 hours including lunch (if the DC is held in the afternoon/evening lunch would be substituted by another longer break, enabling the participants to have a moment of reflection), and furthermore that steps 1-3 are conducted before lunch and steps 4-7 afterwards. The recommendation is based on the adaption to the transport sector and is based on the results of the actual case applications, even though Phillips (2006) reports about a one day application, stating that it is not a good idea, due to the lack of overnight reflection which he claims contributes to the process.

The SWOT matrix below is based on my experience gained from the case studies and on the feed-back I got, when it was presented at the UKSS conference 2009, and can be used for further development of the DC classification proposed in this PhD thesis.

The SWOT matrix indicates that the SDCs have many strengths and opportunities which are helpful in the transport planning process but also some weaknesses and threats to deal with. Introduction of other types of decision models as the underlying technology for the on-the-spot modelling could help introduce SDCs with other features of value for an interactive process in these smaller transport planning projects.

| Strengths | Weaknesses |
|---|---|
| • Presents a short version of DCs<br>• Is applicable to transport planning<br>• Combines group process, and decision analysis with IT<br>• Provides a structured debate<br>• Generates new and broader input for the planning and decision making process<br>• Can evaluate or validate an EIA<br>• Can help to conduct a scanning in the early planning phase<br>• Can shed light on areas of the planning process that need more attention and indebt work | • Selection of focus can be difficult<br>• Short conferences (½-1 day) do not cover as much as a long version (1½-2½ day) and can cause the facilitation style to change into something more like a structured meeting<br>• Time constraints have large impact on the debate and the program<br>• Need of CBA data in the COSIMA decision model is used |
| **Opportunities** | **Threats** |
| • SDCs make the concept of DCs more applicable for transport planning<br>• Testing of decision models with different features of value for an interactive process<br>• Use of Internet enquiries within the process<br>• Development of validation processes to compare with other methodologies | • May mislead people to think that only short conferences are necessary<br>• May have a combination of stakeholders which are not representative<br>• Some strong stakeholders may dominate too much (even though it is the job of the facilitator to ensure a fair debate) |

**Table 13 SWOT matrix of the developed SDCs**

## *3.5 Problem situation approaches and sustainability*

In Chapter 2 it was described that transport planning problems are often messy and, if so, can be considered as either contained problem situations, open-ended problem situations or wicked problems. To be able to deal with the complexity of the problematic situations, it has been explored if systems thinking can be helpful with regard to transport planning processes. Furthermore, the concept of sustainability has been explored to obtain an increased understanding of what it means and how it can be operationalised in transport planning and decision making.

This PhD thesis explores if and how the concept of sustainability can be operationalised in transport planning, which has led to four new approaches to problem solving relevant in the context of sustainable transport planning and decision making. The method developments are all based on a multi-methodological approach and are as previously described named: semi-soft methods, CSSF, DST, and SDC. The methods proposed and treated in detail in the following Chapter 4 are presented in overview in Table 14.

| Semi-Soft methods: | Critical Soft Systems Framework (CSSF): | Decision Simulation Technique (DST): | Short Decision Conference (SDC): |
|---|---|---|---|
| • Can be done by one person (a well-informed analyst)<br>• Imagined stakeholder input (with some uncertainty)<br>• Soft methods used without participation<br>• Information about a problem situation and its stakeholders<br>• Useful for previews and input in the early phase of planning | • Completed by an analyst and stake-holders<br>• Helps to structure and understand the problem situation<br>• Modelling in 'systems thinking' about the real world<br>• A critical approach considering boun-dary judgements<br>• Consists solely of soft methods<br>• Includes stakeholder participation | • Completed by an analyst<br>• Can simulate a point of view, using an 'advocate'<br>• Pre-decision making information regarding the decision problem, stakeholders and preferences<br>• Can help to reduce the number of alternatives<br>• Creates input for the decision making process | • Completed by participating stakeholders<br>• Structured debate, Group processes, IT<br>• Accommodates groups of different sizes<br>• Accommodates groups consisting of either 'all stakeholders' or 'experts'<br>• Can be conducted in ½-1 day |

**Table 14 Classification of the main contributions of the methodologies treated in this PhD thesis**

In Figure 6 it is shown that when a problem has been found to be complex, and a systemic approach is therefore needed, the four proposed method developments are probable approaches. In Figure 6 the methodologies are, in a schematic way, related to the problem type they are most suited for, and it is showed how this corresponds with the level of complexity.

Figure 6 furthermore illustrates how the complexity level rises from low in 'messy contained change' to high in 'messy wicked problem situations'. Though all four methods can be used in any of the defined problem situation types, Figure 6 indicates which methodology would be the most likely at a given problem type/complexity level. The oval shaped dark green bubbles symbolise each of the three problem situation types. The dark green bubbles are interconnected and the shift from where one methodology is the best to another should be seen as 'floating' depending on the individual task. This is illustrated by the way the light green boxes are distributed within the dark green oval shapes. Semi-Soft methods are very applicable at messy contained changes with a low level of complexity. When the problem situation moves towards a messy open-ended change CSSF and DST will be useful and for messy wicked problem situations a SDC will be the most helpful. The distinction between

where the application of the proposed methodologies will be most useful is based on their specific qualities described in section 3.1-3.4.

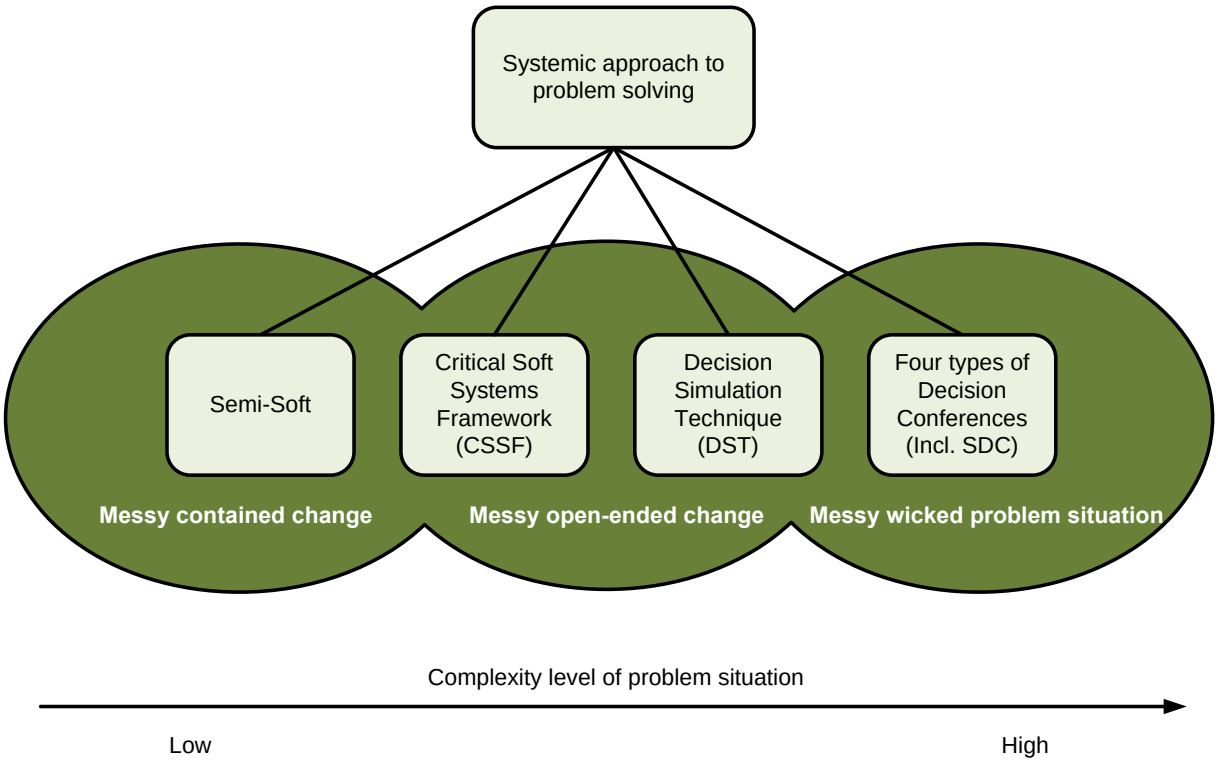


**Figure 6 Four systemic approaches applicable for (complex) problem situations. Note that the suggested approach depends on whether the problem situation is perceived as messy and contained, open or wicked.**

The four proposed methodologies serve to examine the concept of sustainability, which can be used either implicitly or explicitly in the planning process. Whether the concept is used in an implicit or explicit way depends on the actual planning approach and the study purpose. Figure 7 shows how the four methods function in this thesis work.

Specifically, Figure 7 shows that the use of Semi-Soft methods and CSSF can help to operationalise the concept of sustainability in an implicit way. DST and SDCs are used to operationalise the concept of sustainability in an explicit way. The figure furthermore illustrates that semi-soft-methods and DST are conducted by the analyst alone based on accessible information and background material, and that CSSF and SDCs are conducted with stakeholder interaction.

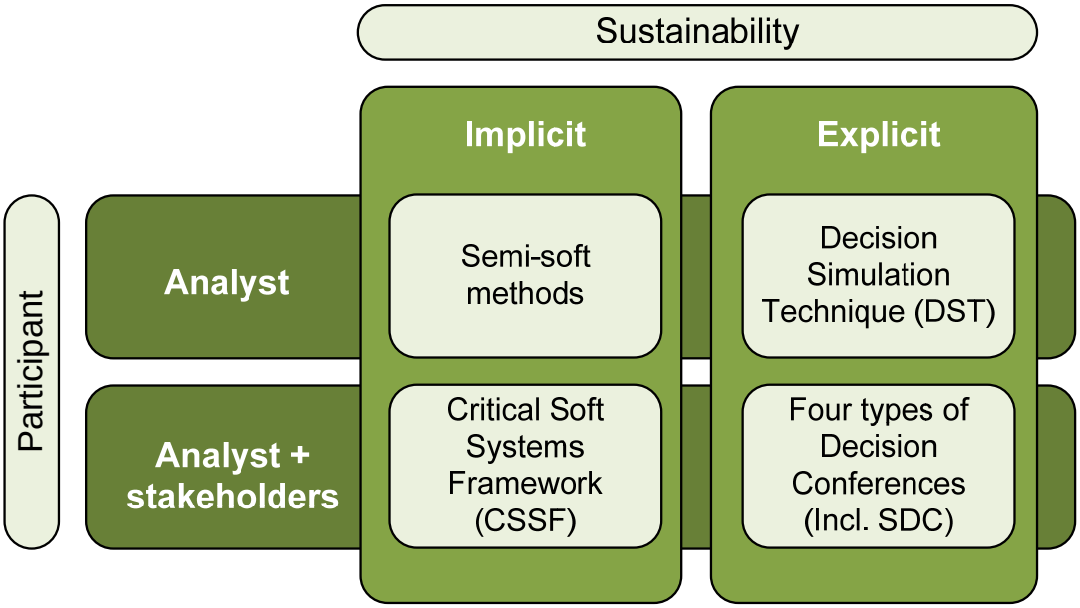


**Figure 7 Relations between the four method developments within this PhD thesis and the concept of sustainability and the involved participants. The concept of sustainability is operationalised as either 'implicit' or 'explicit' and the participants are seen as either the analyst or the analyst together with other stakeholders.**

The proposed methodologies Semi-soft methods, CSSF, DST, and SDCs, were applied to address the operationalisation of the concept of sustainability, see the research questions in section 1.1. As concerns the first research question regarding an operationalisation of the concept of sustainability this is treated using the method developments. As concerns the second research question regarding guidelines for sustainable transport planning the method developments are necessary as elements of a planning framework to be presented and discussed in Chapter 5 after the presentation of papers in Chapter 4.

# 4 Paper presentation and discussion

This section presents the five papers, which have been written during this PhD study and which present the method developments, introduced in Chapter 3, in further detail. The papers address various topics within the areas of transport planning, sustainability operationalisation, and decision support and they relate to the theory and issues presented in Chapter 2 and developed in Chapter 3 with regard to methodology.

As noted, five papers have been written. Four of the papers are published and the fifth and last paper of this thesis is submitted for review for an international journal. All published papers have been peer-reviewed and presented at international conferences and three of the four have been or are accepted for publishing in international journals.

An overview of the five papers is given in Table 15, and the impact areas of the papers are then discussed. Following this, the papers will be introduced by means of a short overview, consisting of information concerning title, author(s) and where and when it has been presented and published, followed by a short paper description and the main findings. Following the overview, the full paper is provided.

| Papers developed during the PhD Study | |
|---|---|
| 1. Paper (section 4.1) Published: 2007/2008 | **Strategic Location Planning: A 'Hard' Approach Supported by 'Semi-Soft' Methods**<br><br>The first paper can be seen as an introduction to the field of multi-methodology decision support and a combination of hard and soft methods. The paper concerns a complex decision process regarding a strategic choice. The paper describes a hard approach to decision making supported by soft methods applied in a so-called semi-soft way. The semi-soft methods were applied to a case regarding relocation of the headquarter of a large knowledge intensive company in the Øresund Region. |
| 2. Paper (section 4.2) Published: 2008 | **Critical Soft Systems Framework (CSSF): A Systemic Framework Combining Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH)**<br><br>The second paper is a theoretical presentation, comparison and combination of two of the main methodologies of this PhD thesis, namely Soft Systems Methodology and Critical Systems Heuristics. CATWOE and the 12 questions of CSH are compared and the 12 CSH questions are afterwards embedded in different phases of SSM in order to support the critical reflection. This paper proposes a multi-paradigm, multi-methodology approach to problem solving by combining Soft Systems Methodology (SSM) and Critical System Heuristics (CSH) in a joined framework named Critical Soft Systems Framework (CSSF). |
| 3. Paper (section 4.3) Published: 2009 | **Decision Simulating Technique (DST) - A 'Scanning-tool' for Planners and Decision Makers**<br><br>The third paper operationalises the concept of sustainability by introducing a simulation tool (Decision Simulation Technique) which can be used in a planning process and provide decision support. The tool is suited as a way of scanning a planning problem. The presented tool Decision Simulation Technique (DST) is applied to a case study regarding the planning of a section part of a railway line in Sweden. This paper demonstrates how sustainability can be operationalised and made explicit in the planning and decision making. |
| 4. Paper (section 4.4) Published: 2009 | **Use of short Decision Conferences (SDC) in Systemic Intervention**<br><br>The fourth paper presents four generic decision conference outlines based on three defined parameters: number of stakeholders, types of stakeholders and time available. The two standard DC types are supplemented by two short types which are better suited for transport planning needs. The two SDCs are applied to two case studies and the use of DCs are related to the concept of sustainability and explication of this in transport planning. |
| 5. Paper (section 4.5) Submitted: 2009 | **Towards a Strategy for Sustainable Planning in Nordhavn**<br><br>The fifth paper presents a case study of an area in Copenhagen, Nordhavn, which will undergo a huge urban development over the next decades. The planning process was modelled using SSM. The main focus is set upon how the concept of sustainability can be operationalised with regard to the development of the area and visions for this development. Sustainability is seen as applicable to either the planning process or the results. The focus is set upon the process and CSH is used for four semi-structured interviews considering what a sustainable planning process is. |

**Table 15 Overview of the papers written during this PhD study**

## 4.1 Paper impact areas

The five papers described in the following sections contribute to the development of an understanding and operationalisation of the concept of sustainability in strategic and complex transport planning. All papers have been based on a systems thinking approach and their main content is outlined in Table 16. From this table it can be seen that four papers concern methodology development and all five papers concern some level of multi-methodology and problem structuring. Three papers deal with decision analysis and/or decision making. All the papers have in different ways related to sustainability, two of the papers deal with implicit sustainability and three of the papers deal with explicit sustainability. Three of the five papers are based on 'real' case studies all within the area of transport planning, one paper is based on a fictive case resembling a real situation and one paper is purely theoretical.

| | Paper 1 | Paper 2 | Paper 3 | Paper 4 | Paper 5 |
|---|---|---|---|---|---|
| Methodology development | X | X | X | X | |
| Multi-methodology application | X | X | X | (X) | (X) |
| Problem structuring | X | X | X | X | X |
| Decision analysis and/or making | X | | X | X | |
| Implicit sustainability | (X) | (X) | | | |
| Explicit sustainability | | | X | X | X |
| 'Real' case application | | | X | X | X |
| Transport case | | | X | X | (X) |

**Table 16 Overview of the five papers of the PhD study**

The paper overview in Table 16 indicates that this PhD study deals with if and how the concept of sustainability can be operationalised in transport planning using a systems thinking approach. There has been a focus on how to structure and deal with complex transport problems and based on experience and findings there has been an emphasis on methodology development based on a multi-methodological approach to decision making. The papers as mentioned have focused on sustainability with examples of both implicit and explicit use.

## 4.2 Overview of paper 1

### *Strategic Location Planning: A 'Hard' Approach Supported by 'Semi-Soft' Methods*

| | |
|---|---|
| Title: | Strategic Location Planning: A 'Hard' Approach Supported by 'Semi-Soft' Methods |
| Author(s): | Jeppesen, S. L., Barfod, B. M and Leleur, S. |
| Presented: | ISOneWorld 2007 conference, Las Vegas, Nevada, USA, 11th-13th April 2007 |
| Published: | Revised and published in Journal of Information Science & Technology (JIST), Vol. 5 No. 3 2008, The Information Institute, Copyright ©2008 by the Information Institute, Washington DC, USA |

**Paper description**

This paper deals with a strategic relocation of a knowledge-intensive IT company located in the Øresund Region. The problem situation can be described as a complex strategic planning problem. For the defined problem situation 8 alternatives were defined and 8 non-monetary criteria were formulated.

The problem situation was addressed by a hard approach supported by soft methods. The applied soft methods are a 'litmus test' of complexity, CSH, Brainstorming, SSM and SWOT analysis and the hard methods applied are preference analysis, CBA, MCA using the AHP[10] and SMARTER techniques, and COSIMA. The hard methods are conducted by the analysts. The soft methods too are conducted by the analysts with indirect stakeholder involvement. This indirect stakeholder participation is based on stakeholders not participating directly, but on the analysts having attained knowledge of needs, company and staff, feeding this information into the process. In this way the analysts simulated the probable preferences of the stakeholders. This approach was chosen to investigate if some of the benefits from the soft methods can be gained without traditional interventions. This use of the soft methods was named 'semi-soft'. The approach is outlined in Figure 8.

[10] AHP is the acronym for 'Analytical Hierarchy Process'

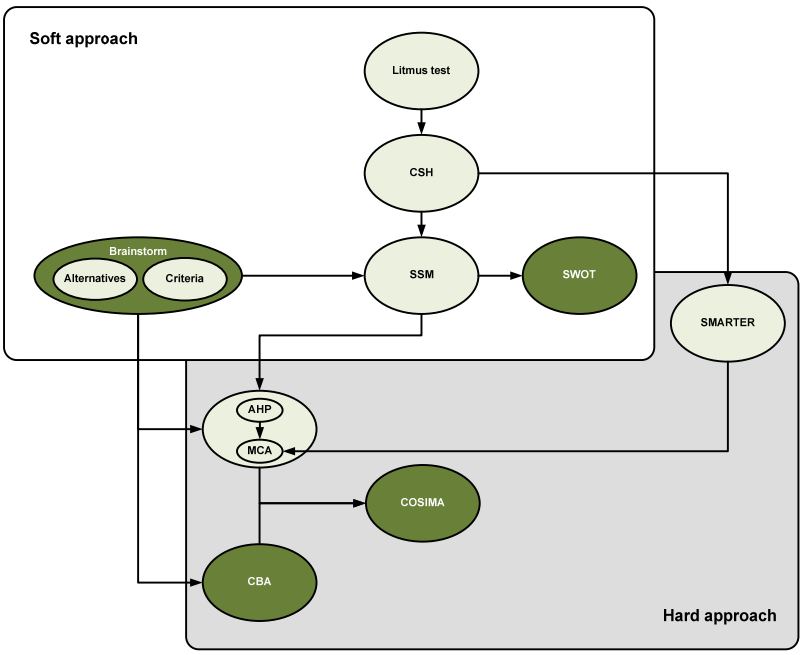


**Figure 8 Flowchart describing the process where the soft methods used in the 'semi-soft' way are embedded in the hard approach, adapted from [Jeppesen et al., 2008].**

## Main findings

Customised decision making can benefit from a multi-methodology approach to the problem situation based on both hard and soft/semi-soft methods. The selection and combination of methods needs to be carefully conducted, every single method should be scrutinised and selected based on the decision makers requirements as a simple increase in the number of methods does not solve the problem. In fact it can lead to a kind of information overload and confuse the decision makers. Semi-Soft methods can provide a broad overview, point in some direction, and set a context whereupon hard methods can provide supplement information and fill in more detailed information.

The suggested hard approach supported by 'semi-soft' input proved to be well suited for dealing with complex strategic planning problems. It was possible to identify key stakeholders and represent their individual preferences in the decision support system.

In the paper semi-soft methods proved to be applicable and highly practical as they provided a useful input for the hard methods, which could not have been gained on the basis of these alone. However, if it is possible to use direct stakeholder participation like in 'traditional' soft methods, this is always recommendable. But if time constraints make it impossible to conduct a participatory intervention, or a pre-planning scanning is demanded, the use of 'semi-soft' methods can then be helpful.

## 4.3 Paper 1 'Semi-Soft' methods

**Strategic Location Planning: A 'Hard' Approach Supported by 'Semi-Soft' Methods**[11]

*The first version of this paper was presented at ISOneWorld 2007, Las Vegas, Nevada, USA and published in the conference proceedings*

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**Abstract**
This paper deals with various methods to support a knowledge-intensive IT company in a strategic relocation of their Scandinavian headquarters in the Øresund Region. Choosing a new location can be regarded as a complex strategic planning problem that calls for a systemic planning approach. This paper considers decision support based on a 'hard' approach supported by 'soft' methods. It describes how 'soft' methods were used by analysts, without direct stakeholder participation, simulating different stakeholders and their probable preferences. Used in this way the 'soft' methods are seen as only "semi-soft". The 'semi-soft' methods were utilised in the customised decision-support system applied in the STMØ project (2005-2007). The input from the 'semi-soft' methods comprises the results gained from a 'litmus test' of complexity, CSH, Brainstorming, SSM and SWOT analyses and the 'hard' approach combines preference analysis, CBA, AHP, SMARTER, MCA and COSIMA. The utilized process consists of several methodologies, some conducted by the consultants and some conducted with indirect stakeholder interference. Finally findings are set out based on an evaluation of the number and choices of methods in the actual case. Based on the relocation case and the various methods applied, the findings recommend that decision support can benefit from a multi-methodology approach and that 'hard' and 'soft' methods should be used

[11] This paper is a revised version of the paper "Comparing a soft and a hard multi-methodology approach: Location of an IT company in the Øresund Region ", which were presented at the ISOneWorld 2007 conference at The Orleans, Las Vegas, Nevada, USA, 11th-13th of April 2007.

in a complementary way. Furthermore, it was found that consultants can obtain benefits from 'soft' methods even though they are used in a 'semi-soft' way.

**Keywords:** Complex planning, decision making, hard methods, soft methods, 'semi-soft' methods, and multi-methodology.

## 1. Introduction

Decision-support systems are widely used to help decision-makers with the difficult task of identifying the best solution to a given problem. There are several approaches to decision support. This paper uses respectively a 'hard' and a 'soft' approach to decision support. Both applications are based on multi-methodology which features a combination of several methods. The 'hard' approach is mainly based on calculations and various computer simulation aids. The 'hard' approach to decision support is highly quantitative and based on the functionalist paradigm within systems thinking. This kind of methods is suited for traditional, non-complex problem situations. For some decisions, numerical values and calculations alone cannot provide the desired decision support. In these cases a 'soft' approach can help to generate the required input. 'Soft' methods are suited to deal with complex problem situations. The 'soft' approach utilised in this case is based on creative methods and analytical processes stemming from respectively the interpretive and the emancipatory paradigm within systems thinking. This kind of analysis is more quantitative in its approach and can provide new and sometimes unexpected angles for the decision support. 'Soft' approaches are traditionally based on stakeholder involvement. In this paper the 'soft' methods will be used solely by consultants acting as the real stakeholders. This provides an indirect stakeholder involvement through the whole case study. This alternative application of 'soft' methods is denoted 'semi-soft' methods. Through this approach it is sought to gain as much from the 'soft' methods as possible, without participation from the stakeholders. This approach is applied in order to investigate if some of the benefits from the 'soft' methods can be gained without traditional workshops and other interactions.

This paper combines the 'hard' and the 'soft' approach, using the 'semi-soft' methods as input for the 'hard' approach. By this combined use the paper seeks to gain benefits from both types of approaches in a less time consuming way. The 'semi-soft' methods can give a broad overview and the 'hard' methods can provide more firm guidance. The decision support is therefore customised to the specific problem so it will suit it in the best possible way.

A case considering a knowledge-intensive IT company who wants to relocate their Scandinavian headquarters in the Øresund Region is analysed. Relocation is a highly strategic question of great importance for any company, so such a decision requires thorough

investigation. Strategic planning problems, such as relocation, have become very complicated because, among other things, they tend to involve several stakeholders. The present relocation case was examined in the STMØ project (2005-2007)[12], see (Carlsson et al., 2008).

This paper examines the process and results of a 'hard' multi-methodology approach applied to the relocation case. The approach consists of several 'hard' methods supported by 'semi-soft' input. The blend of methods is outlined in the flow diagram shown in Figure 9, where the arrows indicate in which order the methods provide information for each other. The process consists of ten different methodologies; 'Litmus test' – identification of whether or not the problem situation is a complex matter, 'Brainstorm' – determining alternatives and criteria for the problem situation, 'Critical Systems Heuristics' (CSH), 'Soft Systems Methodology' (SSM), 'Strengths, Weaknesses, Opportunities and Threats' (SWOT), 'Analytical Hierarchy Process' (AHP), 'Simple Multi-Attribute Rating Technique Exploiting Ranks" (SMARTER), 'Multi Criteria Analysis' (MCA), 'Cost Benefit Analysis' (CBA), 'COmpoSIte Model for Assessment' (COSIMA).

The white box indicates the development of 'soft' input for the 'hard' methods shown in the light grey box. The light green ovals indicate methods which normally are based on participation of stakeholders, and the dark green ovals indicate methods which can be conducted exclusively by consultants. In this case the input will be based on information obtained during the STMØ project.

The paper has the following structure. After this introduction, section 2 introduces the case in sufficient detail to illustrate the relevance of the different methods used. Section 3 presents the different 'soft' methods which are used in a 'semi-soft' way as input generators for the 'hard' approach. In section 4 the decision support process consisting of a 'hard' approach supported by 'semi-soft' methods is presented and conducted based on the present relocation case. Section 5 discusses the case, the process, the selected methods and the participation of stakeholders. Finally, section 6 presents the findings based on the case study in the STMØ project.

[12] STMØ – Strategic Transport Management in the Øresund Region, an EU INTERREG III A Project. STMØ's general purpose is to outline future educational options for a common Danish-Swedish educational programme in Strategic Transport Management (STM) at four of the major universities located in the Øresund Region.

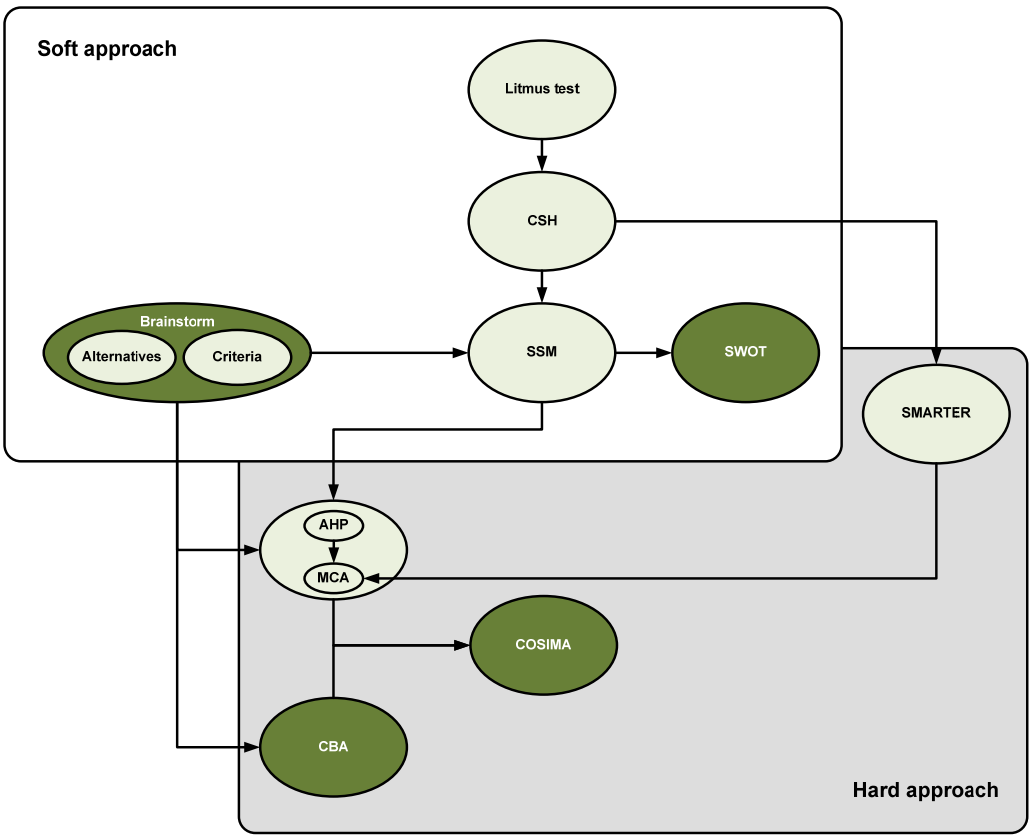


**Figure 9 A flow diagram of the applied process to customised decision support. The process consists of ten methodologies which can be described as a 'hard' approach supported by 'soft' methods. The arrows indicate how and in which order the methods provides information for each other.**

## 2. Case presentation

To illustrate the applied 'hard' approach to customised decision-support and the benefits that can be achieved with an alternative multi-methodology approach, a strategic relocation of a company is analysed. The name of the relocating company is kept anonymous and instead a fictitious company name is used. The 'fictitious' company is, as the real company, a knowledge intensive IT company and is named "Trans-IT Consult" for this case study see (Jeppesen et al., 2007) and (Carlsson et al., 2008). The fictitious company is identical with the real company with regard to employees, size, interest areas, visions and possibilities etc. For the real company the relocation decision was taken by the management without use of a customised decision support tool. For the described case the 'fictitious' company is facing the same challenges as the real company. In this set up the decision support process consists of both 'hard' and 'soft' methods. The whole analysis is conducted by outside consultants, with a firm knowledge of the company and internal relations. The consultants will therefore act as the stakeholder in the 'semi-soft' application of the 'soft' methods.

Using the fictitious company, "Trans-IT Consult", we illustrate how a large company, with focus upon areas such as IT, transport, life science and industry, can deal with a strategic and complex problem situation, in which several different stakeholders and demands need to be satisfied. Furthermore, it is analysed whether 'soft' methods applied in a 'semi-soft' way can gain any important input for the 'hard' approach.

"Trans-IT Consult" is the Scandinavian headquarters of a large international corporation with 15.000 employees worldwide. The company has 200 employees and is presently located in central Copenhagen. However, this location is getting too small and outdated. Since the company wants to consolidate its position in Scandinavia and maintain good worldwide connections, the management wants to relocate the company somewhere within the Øresund Region, see Figure 10 and (Jeppesen et al., 2007) and (Carlsson et al., 2008). This region is considered to be under rapid development and with good connections to other parts of Scandinavia, Europe, and the rest of the world, see (Jeppesen et al., 2006).

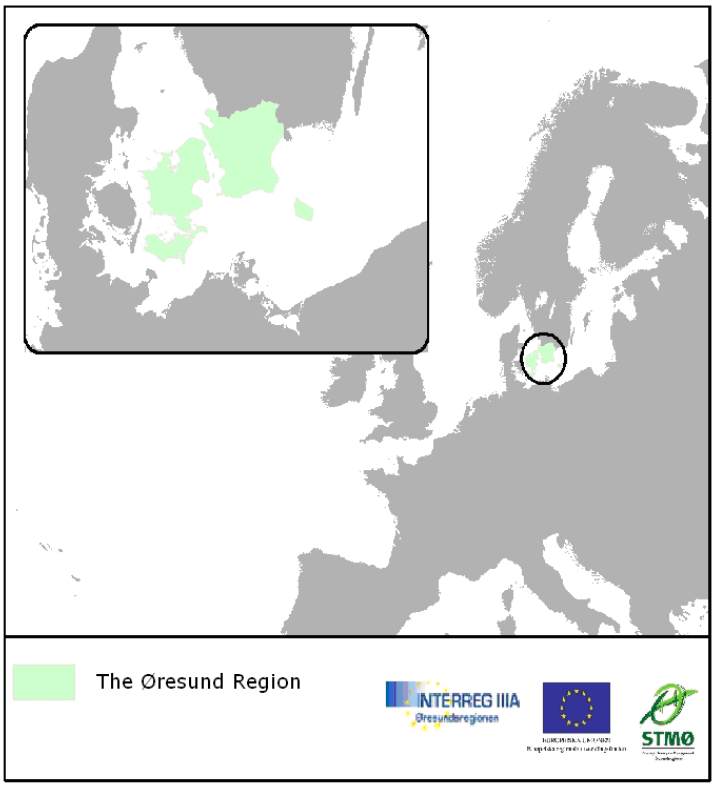


**Figure 10 The Øresund Region, (Jeppesen et al., 2006, p. 6).**

To satisfy the company's requirements, eight different relocation alternatives were identified and prepared for further examination. The eight locations are respectively centrally placed, highly accessible, differently priced, and with different functionality. Some are in Denmark and some in Sweden. Their geographical locations are shown in Figure 11.

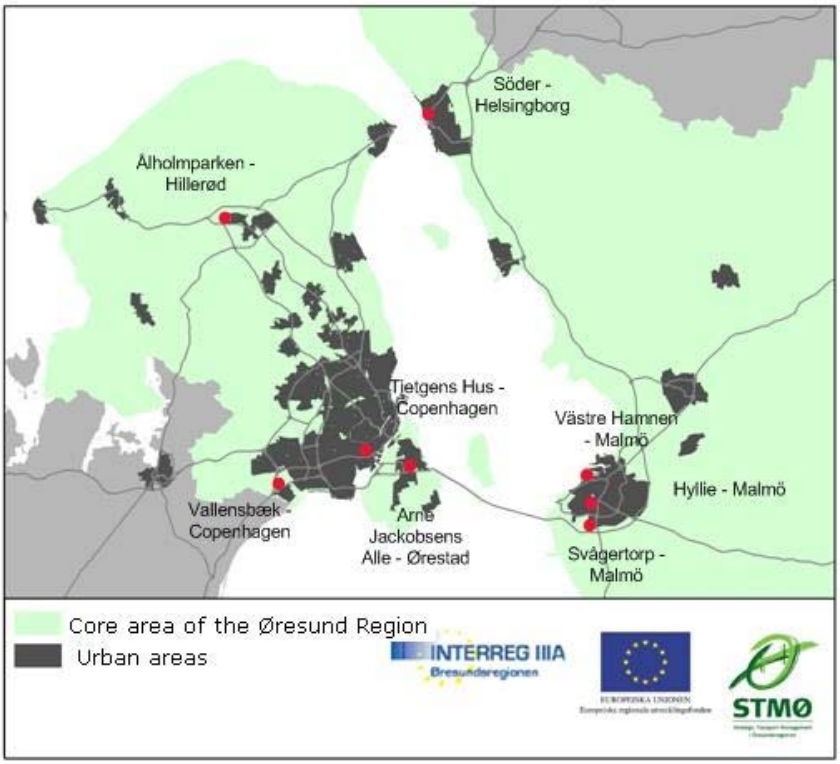


**Figure 11 The eight relocation alternatives, (Jeppesen et al., 2007, p.4).**

| **Denmark** | **Sweden** |
|---|---|
| • Tietgens Hus – Copenhagen C<br>• Arne Jacobsens Allé – Ørestaden<br>• Vallensbæk Torvevej – Copenhagen<br>• Ålholmparken – Hillerød | • Västre Hamnen – Malmö<br>• Hyllie Centrumområde – Malmö<br>• Svågertorp – Malmö<br>• Söder – Helsingborg |

## 3. The blend of 'soft' methods from different paradigms

The 'soft' methods presented in Figure 9, have various theoretical backgrounds since they are related to different paradigms in systems thinking. Five paradigms have been outlined in systems thinking: Functionalist, Interpretive, Emancipatory, Postmodern, and Complexity, see (Leleur, 2005, pp.46-47). Petkov et al. (2006) have shown that the blending of methods in a multi-methodological process based on the ideas of Mingers and Jackson can be justified by Habermas' "theory of the three worlds".

*"Multimethodology, another contribution to pluralist systemic interventions, justifies work across paradigms on the basis of more recent ideas by Habermas – the theory of the three worlds: the material world, the social world and the personal world"* (Petkov et al., 2006).

In the three case studies carried out by Petkov et al. (2006), they also concluded that it was possible to make use of a blend of methods based on different paradigms, but state that further practical work is needed in this field.

Each of the applied methodologies was chosen for its explicit qualities in shedding light on the strategic planning situation. In this case, a combination of the methods was regarded as necessary since there were no stakeholders of the fictitious company Trans-IT consult to participate in the development of the 'soft' approach. Knowing, that 'soft' methods are normally based on participation, the 'semi-soft' use of the methods was introduced. The analysis scrutinizes the 'semi-soft' use of the 'soft' methods and examines whether such an approach can frame an embedded use of 'soft' methods in a 'hard' approach. Stakeholder participation would have been highly beneficial, but the limited time of the participants would have limited the number of methods used, and thereby the conduct of the process. Since such participation was not possible, the blend of methods was created in such a way that this should compensate for the different viewpoints and boundary perceptions that participating stakeholders would have provided. This approached was designed to test the application of 'soft' methods as input for 'hard' methods. Furthermore, the 'soft' methods have been used without direct stakeholder participation in order to test if consultants' singlehandedly can benefit from 'soft' methods. This will, if possible, enable consultants to gain some of the benefits from 'soft' methods and processes, without stakeholder interventions. This will in the cases where 'semi-soft' methods can be applied, help to save time, but still provide broader information than what the 'hard' methods singlehandedly can provide.

Petkov et al. (2006) also found that methods from different paradigms can serve as input for each other in order to guide the stakeholders by application of the different methodologies. In this case the use of several methods provided a lot of information about the particularities of the strategic planning problem including the impact of different viewpoints even though no actual stakeholders were involved.

The first method used in the customised decision support process was the litmus test, which is found in the complexity systems approach, see (Leleur, 2005). This method was chosen to indicate whether the problem situation was complex or not. If the problem was found to be complex, further use of 'soft' methods would be recommended. The second input came from brainstorm sessions which can be regarded as a creative method based on the interpretive paradigm. This methodology provides a creative tool to define the different alternatives for resolving the problem situation and the different criteria under which they will be evaluated. The third method that was chosen was the CSH, which is found in the emancipatory systems approach, see (Jackson, 2000, pp. 315-320). This method provides information and critical

reflection upon stakeholders and their roles in relation to the problem situation. The fourth method used was the SSM, which is found in the interpretive systems approach, see (Jackson, 2000, pp. 246-270). This method can based on its interpretive structure provide a framework, that can gather a broad amount of information and knowledge about interrelations. The fifth method used was SWOT analysis, which is also found in the interpretive systems approach. This method was chosen as it provides an overview of the findings from the previously applied methods. Thereby it gathers information in an easy accusable way. In accordance with the findings in Petkov et al. (2006), the methods were blended together to form the process shown in Figure 9.

| 'Soft' input for the 'hard' approach | |
|---|---|
| **Method** | **Purpose** |
| **Litmus test** | Indicates if the problem situation is complex or not |
| **Brainstorm of criteria and alternatives** | Identification of possible criteria and locations |
| **CSH** (Critical Systems Heuristics) | Defines the boundaries of the planning problem |
| **SSM** (Soft Systems Methodology) | Defines human, social and political interference and provides structure |
| **SWOT** (Strengths, Weaknesses, Opportunities and Threats) | Defines SWOTs in the findings and in the results of the previous |

**Table 17 The 'soft' methods which have been used to generate input for the 'hard' methods, adapted from (Jeppesen et al., 2007, p.5).**

### 4. The 'hard' method approach supported by 'semi-soft' input

The 'hard' methods outlined in Figure 9 are all founded in the functionalist paradigm within systems thinking. These methods are performing very well in non-complex environments. To state if the relocation case was a complex matter, a litmus test of complexity was conducted. It determined that the relocation issue was a complex planning problem. Such a complex problem situation calls for application of a multi-methodological approach, see (Leleur, 2005) and it was chosen to base the application of the designed 'hard' approach on input stemming from the use of 'semi-soft' methods combining different paradigms.

Initially conduct of the SSM, see (Checkland, 1993/1999) and (Jackson, 2000), identified many of the relations and boundaries of the strategic planning problem and thereby focused the process of relocating the company. Using SSM, four problem areas were defined from the primary problem. These were specified by the use of the root definitions tool with in SSM. The root definitions defined: where to move to; what criteria to apply, which of these to prioritise, and how to consolidate/improve the image of the company, as the main themes in the problem situation. The conceptual models which were developed as a part of the SSM application indicated, that a solid result could be obtained by involving stakeholders. This would provide useful inputs, but might also complicate the process. Influences from the root

definitions and the 'fictitious' stakeholders were identified and categorised using SWOT analysis, see (Zwaenepoel, 2004). The analysis showed both pros and cons related to the decision process. However, the revealed strengths and opportunities outnumbered the weaknesses and threats. One general advantage of the proposed customised decision support process shown in Figure 9, is that a lot of different opinions and alternatives can be taken into consideration. One general disadvantage can be, that too much information is overwhelming and possibly confuse the decision-makers so that they feel forced to use a simpler process in order to take the decision. The analysis of the proposed design of a customised decision support process showed, that this problem can be remedied to some extent by using a consultant as coordinator or facilitator.

To obtain an assessment of all the impacts identified by the 'semi-soft' methods a so-called composite model for assessment (COSIMA) was applied (Leleur et al., 2007). COSIMA has over the past years been applied to various cases, as it can provide a combined assessment of a variety of alternatives with regard to both monetary and non-monetary impacts. The COSIMA approach consists of various methodologies, which individually underpin and support each other, see Table 18.

| 'Hard' approach | |
|---|---|
| **Method** | **Purpose** |
| **CBA** (Cost-Benefit Analysis) | Evaluation of monetary impacts |
| **AHP** (Analytical Hierarchy Process) | Pairwise comparison of alternatives, based on criteria. Development of value-function scores |
| **SMARTER** (Simple Multi-Attribute Rating Technique Exploiting Ranks) | Applying ROD-weights to the ranking based on importance of criteria |
| **MCA** (Multi-Criteria Analysis) | Evaluation of non-monetary impacts |
| **COSIMA** (COmpoSIte Model for Assessment) | MCA and CBA are combined and added appropriate weights for the decision as they are rated together |

**Table 18 The methods used for the 'hard' approach, (Jeppesen et al., 2007, p.8).**

The COSIMA approach seeks to combine cost-benefit analysis (CBA) and multi-criteria analysis (MCA) in a comprehensive type of assessment, where the socio-economic (monetary) and the societal (non-monetary) attractiveness of each alternative is expressed by a total rate of return (TRR). The technique behind the COSIMA approach is described in detail in (Leleur et al., 2007). The following 'hard' examination of the relocation case is based upon the STMØ project (2005-2007) see (Jeppesen et al. 2007) and (Carlsson et al., 2008).

Two brainstorm sessions were used to provide information regarding which criteria and alternatives to assess. Both of these factors have great influence on the outcome of all the 'hard' methods in the COSIMA analysis, as they define the content and boundaries of the

analysis. The selected alternatives are outlined in section 2 and the influential criteria are shown in Figure 12. The criteria were divided into two groups with costs and benefits, and the benefits have been further divided into different sub-criteria. Furthermore, Figure 12 indicates the criteria which are dealt with in respectively the CBA and the MCA.

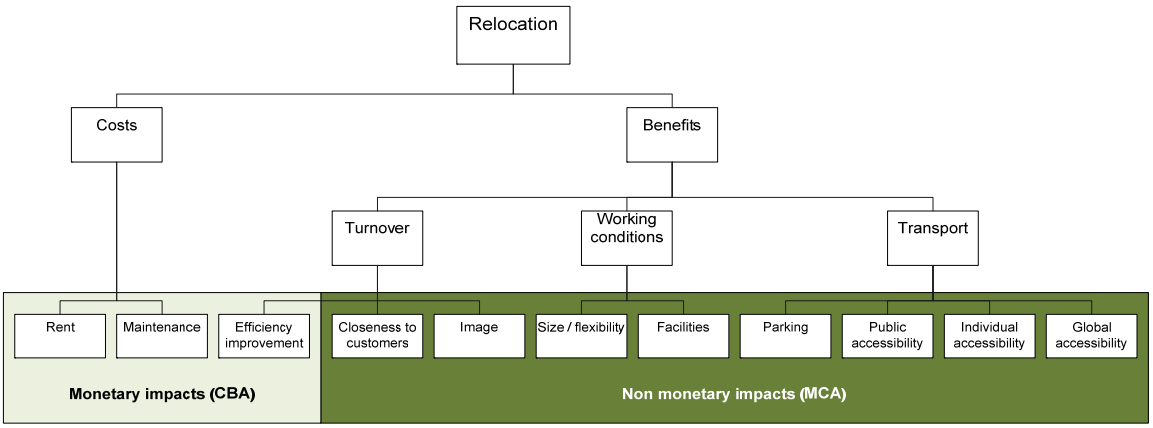


**Figure 12 Criteria used in the decision process, (Jeppesen et al., 2007, p.5).**

A conventional cost-benefit analysis (CBA) deals with the monetary impacts, in this case a 15-year evaluation period is considered. The costs (rent and maintenance) were implemented in the CBA as the difference between the present location's costs and these of the alternative. One type of benefit from changing location is the efficiency improvement which is measured and estimated in saved working hours. The CBA also included the net changes in rent and maintenance costs as well as company salary costs over the evaluation period. The latter is due to differences between Denmark and Sweden. The results of the CBA are given as single point estimates in form of benefit-cost rates (B/C-rates), see Table 19. In order for an alternative to be feasible the B/C-rate has to be above 1, which means, that the benefits of the alternative are larger than the costs.

| Alternative | B/C-rate |
|---|---|
| Tietgens Hus – Copenhagen | 1.00 |
| Arne Jacobsens Allé – Ørestad | 0.80 |
| Vallensbæk – Copenhagen | 2.40 |
| Ålholmparken – Hillerød | 1.25 |
| Västre Hamnen – Malmö | 2.07 |
| Hyllie – Malmö | 3.05 |
| Svågertorp – Malmö | 2.83 |
| **Söder – Helsingborg** | **3.64** |

**Table 19 B/C rates for the eight alternatives, (Jeppesen et al., 2007, p. 9).**

The CBA results clearly show that Söder–Helsingborg would be the best alternative if the decision is based solely on monetary considerations. Only one alternative, Arne Jacobsens Allé, would not be profitable according to this analysis.

To determine the impact of the non-monetary effects, it is necessary to perform a multi-criteria analysis (MCA). The MCA assigns a value to the effects that can be used for a composite assessment with the CBA. The stakeholder groups have different preferences towards the non-monetary effects as they have different relations to the company and the relocation of it.

In order to obtain an assessment as objective as possible CSH was used to provide the decision-makers with information about known and unknown boundaries, associated areas, and stakeholder groups, (Ulrich, 2005). The analysis was carried out in an "is" as well as in an "ought to" mode. Summarised two important stakeholder groups were identified representing two different levels in the company: the management and the employees. These two groups of stakeholders have very different preferences, which will have very different impacts on the decision process. The CSH analysis also revealed, that the most important factors in the "is" answers are space, image and an accessible location, followed by "ought to" factors such as better facilities, easy accessibility to customers and easy access for employees as far as private and public transport is concerned. Global access was also regarded as very important. The managers have the responsibility, and can, if they want to, involve the employees to influence the decision, but the most important resources in the process are time and money.

Using the analytic hierarchy process (AHP) method, see (Saaty, 2001), preferences of the two identified stakeholder groups were considered in full pairwise comparisons of the eight alternatives within all eight criteria. The scores obtained by the comparisons were computed into value function scores (VF-scores) by use of a local scale as described in (Belton & Stewart, 2002) and further developed in (Leleur & Barfod, 2007). These Value function scores (VF-scores) are a measure for how each of the eight alternatives are performing within each of the criteria. The Value Functions are constructed so the value 100 is describing the best performing alternative and 0 the worst performing. The intermediate alternatives are assigned with a score according to a linear assumption. The results of the AHP-comparisons in form of VF-scores are shown in Figure 13.

The results show that Arne Jacobsens Allé had the overall best performance within the eight non-monetary criteria and that Söder–Helsingborg had the worst overall performance. These results show that Arne Jacobsens Allé was found to be the alternative which suited the eight non-monetary criteria best. This means that this alternative would be chosen if the decision were made solely based on the non-monetary criteria. This result is opposite to the CBA, and

it is therefore interesting to examine the weighted performance of the alternatives if the MCA and the CBA are brought together in a composite model assessment.

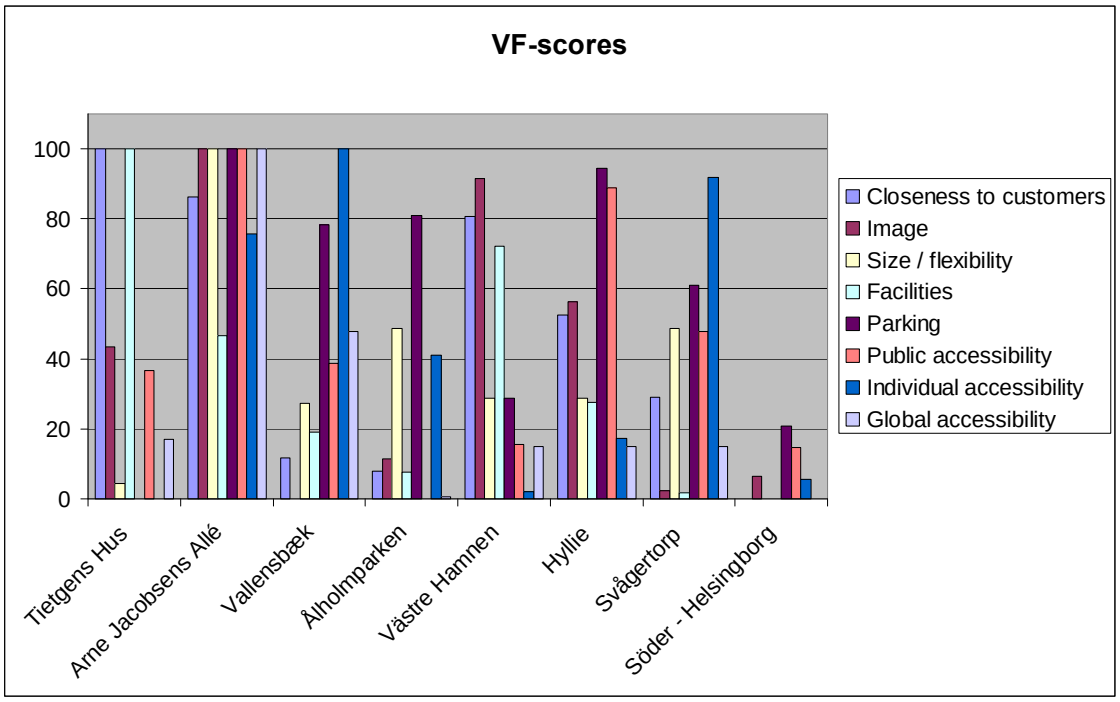


**Figure 13 Value-function scores showing the performance of the alternatives within the criteria, (Jeppesen et al., 2007, p.10).**

To determine criterion weightings in order of importance, the SMARTER method, see (Goodwin & Wright, 1998), was applied with the so-called Rank Order Distribution (ROD) weights, see (Roberts & Goodwin, 2002). This simplifies the decision-making because it only requires the decision-makers to rank the MCA criteria in order of importance. No specification of the weightings is needed since these are determined by the ROD technique.

To examine the importance of the ranking of the criteria, and thus the preferences of the decision-makers, the rankings of the two identified stakeholders were considered. One ranking was made on the basis of the estimated preferences of the management and another on the basis of the employees' estimated preferences. These two rankings are very different from each other as the managements interests are in maximising the company income while the employees are more interested in good working conditions. The rankings were then assigned ROD weights, see Table 20, and multiplied by the VF-scores in accordance with the principle of COSIMA.

Finally the decision-makers' trade-off between the CBA and the MCA was determined (what percentage should MCA count against CBA). The trade-off is measured on a relative scale, so

it is important to note that no information is taken from the CBA result by this procedure, there will only be added MCA information. In this way, all the input for COSIMA was obtained and the attractiveness of the alternatives could be determined and calculated as the Total Rate of Return (TRR). The TRR indicates the composite attractiveness of each alternative.

| Priority | Management | Employees | ROD-Weight |
|---|---|---|---|
| 1 | Image | Individual accessibility | 0.2292 |
| 2 | Closeness to customers | Public accessibility | 0.1977 |
| 3 | Global accessibility | Facilities | 0.1672 |
| 4 | Facilities | Parking | 0.1375 |
| 5 | Individual accessibility | Size / flexibility | 0.1084 |
| 6 | Public accessibility | Image | 0.0805 |
| 7 | Parking | Global accessibility | 0.0531 |
| 8 | Size / flexibility | Closeness to customers | 0.0263 |

**Table 20 ROD-weights assigned to the two stakeholder rankings of the defined criteria, (Jeppesen et al., 2007, p. 11).**

The level of the trade-off was defined based on the stakeholders' opinions on how large importance the monetary respectively the non-monetary criteria should have on the decision. In a case like this one, where a company wants to maintain strategic competitive strengths by relocation in a region with emphasis on a strong profile, we would expect non-monetary strategic impacts to be assigned more importance than monetary impacts. We think it not unlikely, for example, that the decision-making would be based on a TRR calculated with a 70% weighting for the MCA part. However, the size of this weighting (or trade-off) would vary depending on what kind of project is being evaluated.

The variation of the TRR for both stakeholder rankings is shown in Figure 14 and Figure 15, respectively. Only the alternatives with relevance for the decision-making are shown in the two figures. Both figures show the TRR of the alternatives at different levels of trade-off. The different trade-off values indicate different approaches to decision making. The trade-off value should be determined before the graph is generated, so this information does not affect the decision.

The 'fictitious' management stakeholder group assigned high importance to criteria such as image, closeness to customers and global accessibility. Accordingly, alternatives with high VF-scores for these criteria attained a larger TRR than alternatives with low VF-scores as the MCA part was assigned increasing weight, see Figure 14.

If a low weighting is given to the MCA part (and hereby a high weighting to the CBA), the most beneficial alternative would be Söder–Helsingborg. With increasing weight on MCA, Hyllie achieves the best TRR because this location scores higher on these criteria. Finally, Arne Jacobsens Allé achieves the highest TRR with high weighting of the MCA part, which is, of course, a result of the alternative's higher scores in the MCA. This implies that the attractiveness of the alternatives is very sensitive to the chosen trade-off value, which can be difficult to determine. In order to account for a certain extend of uncertainty in the appraisal, the decision-makers could be encouraged to base their decision upon a short trade-off interval rather than a single point value.

The 'fictive' employees stakeholder group assigned greater importance to different criteria from those of the management (first individual accessibility, then public accessibility, followed by good facilities) (Figure 14 and Figure 15 shows the different TRR results). However, the same three alternatives still have the best TRR, although within modified intervals, see Table 21.

Figure 14, Figure 15 and Table 21 show that the decision-support produced depends greatly on how much weight is assigned to the MCA part, for three different alternatives are the most attractive within different intervals. The final decision-making should, however, not in all situations be based upon considering an interval, but should also seek to scrutinise which CBA/MCA trade-off actually expresses the decision-makers' preferences best and thereby obtain an unambiguous result.

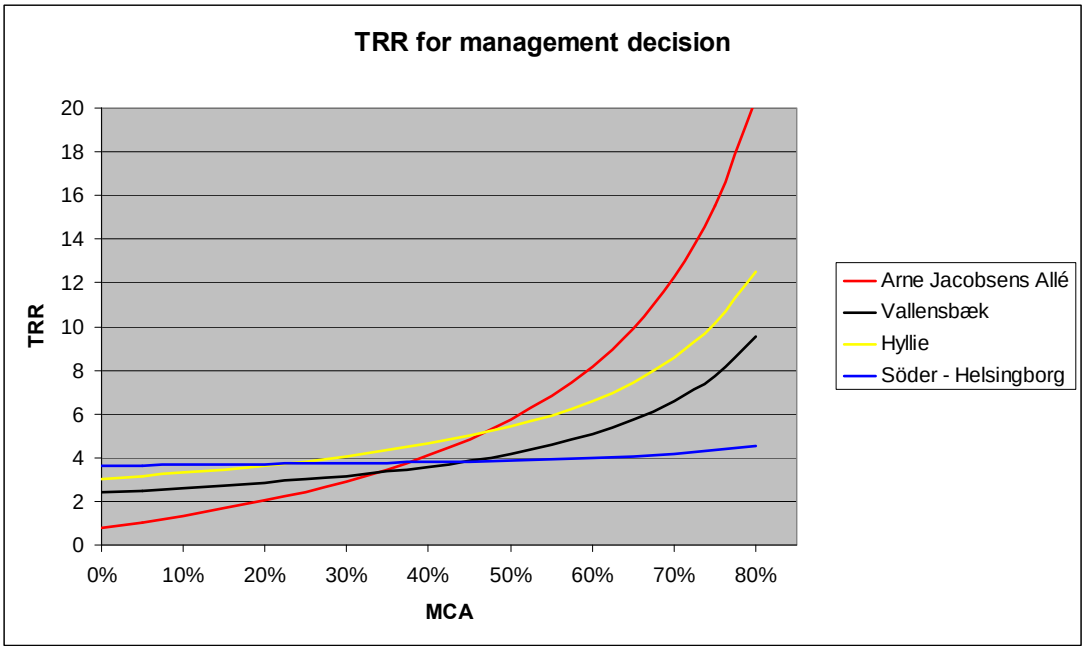


**Figure 14 TRR according to the management decision-making, (Jeppesen et al., 2007, p. 12).**

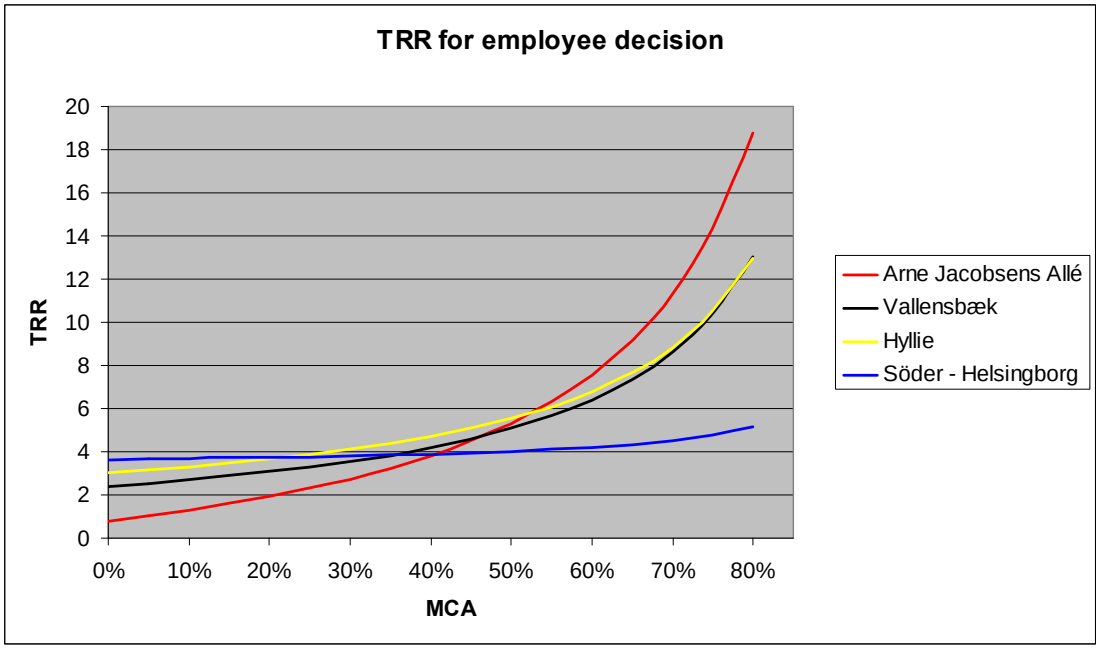


**Figure 15 TRR according to the employee decision-making, (Jeppesen et al., 2007, p.12).**

| Managers | Alternative | Employees |
|---|---|---|
| Interval | | Interval |
| 0-25 % MCA | Söder-Helsingborg | 0-25% MCA |
| 25-45% MCA | Hyllie | 25-55% MCA |
| 45-100% MCA | Arne Jacobsens Alle | 55-100% MCA |

**Table 21 Interval results of the decision, (Jeppesen et al., 2007, p. 13).**

## 5. Discussion and findings

The examined multi-methodology process for customised decision support was set out to provide the planner with a suitable approach to deal with a complex planning situation. In these situations a special emphasis on input from stakeholders and their interrelations are needed. This was coped with by embedding input from 'soft' methods in the more conventional 'hard' calculations of alternatives and criteria. Specifically, the research question addressed was whether the introduced use of 'semi-soft' methods are adequate to frame and structure a more 'hard' approach, in this case consisting of a decision support system made up by a combined cost-benefit and multi-criteria analysis. The 'semi-soft' methods are denoted so instead of 'soft' methods as analysts simulate the probable preferences of different stakeholders.

The multi-methodology approach presented in this paper is well suited for complex planning situations such as the present. The multiplicity of the methods shows the problem area from different viewpoints and indicates that the defined problem situation is not fully understood,

but needs more exploration. With the ‘hard’ approach based on the input developed by the ‘semi-soft’ methods we were able to identify how different stakeholder groups, in a complex environment, would rate the different alternatives and thereby how the decision can be influenced by different preferences. The ‘soft’ methods proved to be applicable in a ‘semi-soft’ way, as they in this sort of application still provided helpful information that could not have been derived solely from the ‘hard’ methods. Used in the ‘semi-soft’ way the ‘soft’ methods acted as a helpful tool for the consultants as they could gain benefits from ‘soft’ methods and stakeholder participation, without conducting real intervention. However the use of ‘real’ stakeholder participation is recommended where it is possible as this gives full benefit to the theory and application of the ‘soft’ methods. The ‘semi-soft’ application of ‘soft’ methods will serve as a good tool for planners in cases that are under a large time pressure or in cases where a screening is conducted before a larger analysis.

Another general finding of the work is that the complexity of the strategic decision problem turns out to imply, that there is no definite methodological advice to be given, but many possible solutions. Another more specific finding from the STMØ case exercise is that an approach consisting solely of ‘hard‘ methods leads to definite proposals, but that these may not ensure that all the information has been obtained and used. Thus it has been demonstrated that ‘semi-soft’ methods can be very useful in assisting (“embedding”) a ‘hard’ approach as their use influences the planning outcome. Furthermore, the ‘soft’ and ‘hard’ methodologies selected are shown to be important for the formation of the decision process and the results achieved.

In this paper, several different methodologies were used with relative success, but in general increasing the number of methods will not be a solution. The single method needs to be scrutinised and selected in relation to the decision-makers’ requirements for information.

In the STMØ case, where the stakeholders were not directly present, the number of methods was found to be suitable bearing in mind that the fictitious stakeholders represented by the consultants, among other things, were eager to test a wide spectrum of methods. However, in cases, where real stakeholders would participate during the whole process, this particular approach might prove to be too extensive. As the ‘hard’ methods of the process are regarded as a “package” making up a decision support system, the number and choice of these should remain unchanged within the presented process.

The fact that the case study was conducted on the basis of a fictitious company closely related to a real company was both beneficial and challenging. The similarity to a real case provided useful information and an opportunity to present the outcome of the case study after its

completion. The fact that it was not possible to use any real stakeholders was a big challenge. To fill the gap, the involved consultants acted as stakeholders. The results, however, were found to visualise the advantages obtained by the applied approach, as the 'semi-soft' use of the 'soft' methods were found both possible and helpful.

An important issue arising from the case study being "a private company" is that the management is completely free to make whatever decision they find best, even if it contradicts the results of a conducted analysis, stakeholder preferences, and/or other inputs. The fact that the decision-makers consult customised decision-support systems does not imply that the decision-support advice will be followed. However, if the decision-makers do make use of the decision-support provided, this might ensure a smoother process with the stakeholders being given the opportunity to comment on the findings during the process. In this case we found that the TRR for the top 3 alternatives vary in-between the two stakeholder groups. In order to obtain the most beneficial relocation the decision makers need to find a solution that suits all, but in the present case with a MCA level of 70% this is not an issue as both stakeholder groups prefer the same alternative.

Summarising this work with 'semi-soft' methods it seems both probable – but also highly practical – that fewer methods may be worthwhile to consider with real world planning problems. In cases with direct stakeholder interaction 'soft' methods should replace 'semi-soft' methods, but otherwise 'semi-soft' methods embedded in a 'hard' approach is seen as a promising approach, which, however, needs further thorough investigation.

**Acknowledgements**

This paper is based on research in the INTERREG IIIA project Strategic Transport Management in the Øresund Region (STMØ). The fictitious case study was defined and carried out by the Decision Modelling Group (DMG), the Centre for Traffic and Transport (CTT) at the Technical University of Denmark (DTU).

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## 4.4 Overview of paper 2

### *Critical Soft Systems Framework (CSSF): A Systemic Framework Combining Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH)*

| | |
|---|---|
| Title: | Critical Soft Systems Framework (CSSF): A Systemic Framework Combining Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH) |
| Author(s): | Jeppesen, S. L. and Paucar-Caceres, A. |
| Presented: | UKSS 2008 conference, Oxford, England, 1st-3rd September 2008 |
| Published: | The Systemist Vol. 30 (4) 2008, pp. 173-195, the United Kingdom Systems Society |

**Paper description**

This paper deals with the possibilities of a combination of Critical Systems Heuristics (CSH) and Soft Systems Methodology (SSM) into a joint use within the proposed Critical Soft Systems Framework (CSSF). The CSSF was developed based on scrutinising the two methods with a focus on the individual limitations of each of the methods. SSM is suggested as the platform for CSSF, and it is proposed to be improved by the 2x12 questions from CSH. The 'is'-mode questions are incorporated in the 'finding out' part of SSM and the 'ought to'–mode of the questions are included in the 'modelling' part of SSM. The amalgamation of the two methodologies into a joint framework led to considerations regarding the use of multi-paradigm multi-methodology as the two methods stem from different paradigms. SSM is based on the interpretive paradigm and CSH on the emancipatory paradigm.

**Main findings**

The limitations of SSM were found to be related to analyses 1-3 and the CATWOE analysis. It was found that without firm guidelines, there is a risk that the questions asked are within a single or a few worldviews and that a "positive atmosphere" will leave out critical questions and reflections. The skills and methodological knowledge of the facilitator is also found to be a possible limitation. Furthermore, it was found that CATWOE can be said to be both too broad and too narrow as it covers a lot of information, but without any reflection as the problem situation is analysed through the worldview with which it is stated in the root definition. The most important limitation is the lack of critical reflection. The limitations can be seen as a symptom of the interpretive paradigm where SSM belongs as it encourages a divergent process and interpretation of the situation, but does not directly facilitate critical

reflection. The strengths of SSM is that it provides a platform for problem structuring and solving and that the methodology can be perceived to be mature with several supportive tools.

The limitations of CSH were found to be that boundary critique alone is not enough. It is important that CSH is combined with problem-structuring and problem-solving techniques. The strengths of CSH is that its 12 questions can be useful in relation to other methods, and especially the modelling part of SSM, where purposeful models are developed. Through the 12 questions CSH can help to 'emancipate' SSM. Relations between the two methodologies and their parts/tools relation to the real world and systems thinking about the real world is shown in Figure 16 (see paper 2 for a larger version of the figure).

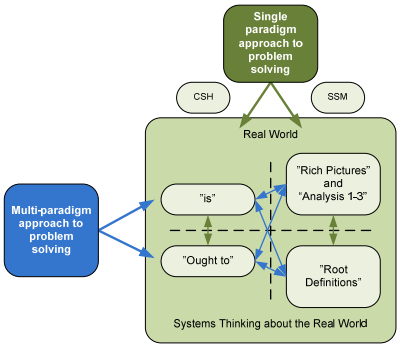


**Figure 16 Relations of SSM and CSH, adapted from (Jeppesen & Paucar-Caceres, 2008)**

Several similarities were found between CATWOE and the 12 questions of CSH. Figure 17 illustrates a comparison of CATWOE and the 12 questions of CSH, where related questions are indicated with black lines (see paper 2 for a larger version of the figure). It can be seen how two of the CATWOE questions are covered by several questions in CSH and how CSH has a broader palate of questions than CATWOE, for which reason CSH offers a broader reflection possibility with regard to the problem situation in question. Figure 18 illustrates the outline of CSSF, where the 12 questions of CSH are implemented in the SSM platform (see paper 2 for a larger version of the figure). This framework is finally proposed as a way to deal with the limitations of the two individual methodologies.

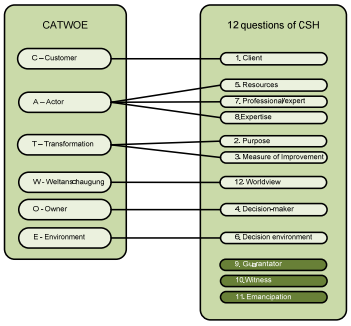


**Figure 17 Comparison of CATWOE and the 12 questions of CSH, adapted from (Jeppesen & Paucar-Caceres, 2008)**

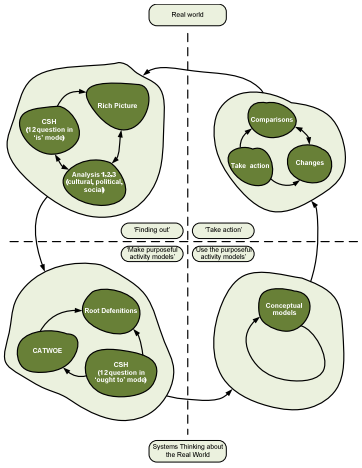


**Figure 18 Outline of the CSSF, adapted from (Jeppesen & Paucar-Caceres, 2008)**

## *4.5 Paper 2 Critical Soft Systems Framework (CSSF)*

**Critical Soft Systems Framework (CSSF): A Systemic Framework Combining Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH)**

*Presented at UKSS 2008, Oxford, United kingdom*
*Published in The Systemist Vol. 30 (4) 2008, pp. 173-195, United Kingdom Systems Society*

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**Abstract**
This paper proposes a systemic framework, Critical Soft Systems Framework (CSSF) that provides conceptual guidance for a joint use of Critical Systems Heuristics (CSH) and Soft Systems Methodology (SSM). Based on SSMs general platform of enquiry we argue in favour of a systemic amalgamation of the two methodologies. The SSM phases of "finding out" and "modelling" are improved by introducing critical tools developed by CSH. The paper contributes to recent debates on multi-methodological practice in management science, proposing a novel conceptual framework in which these two methodologies stemming from two paradigms (interpretative and emancipatory) can be compared and combined in a coherent systemic tool.

**Key words**: Systems Thinking, Critical Soft Systems Framework (CSSF), Soft Systems Methodology (SSM), Critical Systems Heuristics (CSH), Multi-methodology, Multi-paradigm

**1. Introduction**
Recent developments in Management Science have indicated the emergence of what is called multi-methodology, a practice that combines techniques, methods and methodologies from the same or different systems thinking paradigms, see (Mingers, 1997a, 1997b), (Mingers & Brocklesby, 1997), (Jackson, 1997, 1999) amongst others. Multi-methodological practices combining methods and techniques from across the hard and soft systems methods spectrum have been widely reported in (Mingers, 1997a), (Munro & Mingers, 2002), (Brocklesby, 1995, 1997), (Paucar-Caceres & Rodriguez- Ulloa, 2007) amongst others.

This paper contributes to multi-methodological practice in management science by proposing a conceptual framework, Critical Soft Systems Framework (CSSF) in which some stages of Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH) are combined. The proposed framework brings together the best features of both SSM and CSH. Based on SSMs general platform of enquiry we argue in favour of a systemic amalgamation of the two methodologies in which the SSM phases of "finding out" and "modelling" are modified by introducing the critical features and tools developed by CSH.

As it has been widely reported, Soft Systems Methodology (SSM) was developed by Checkland and his colleagues in Lancaster in the early 70s to cope with the limitations of traditional 'hard' OR, (Checkland, 1981/1999). The methodology differs from these approaches as it is an iterative learning process that emphasises the process rather than results and correct solutions. The methodology is developed within the interpretive systems approach, and it is thereby an exploratory methodology which leaves room for creative techniques and approaches to problem solving. SSM provides useful information on the problem situation in question in terms of social, political and cultural matters and help to provide change. Stakeholder participation and willingness to share information provides the best application of SSM, though it can be performed in a non participatory way.

On the other hand, Critical Systems Heuristics (CSH) was developed in the 80s by Ulrich (1987). The methodology was designed to provide a practical tool for planners and concerned citizens with information about actual situations and systems designs. The CSH methodology is embedded in the emancipatory systems approach, and seeks to provide emancipation for suppressed groups in any given problem situation, (Jackson, 2000). The framework provides 12 accurate questions which can be presented in either an "is" or an "ought to" mode, which can provide information about the situation as it is now and how it ought to be. By asking critical questions, the methodology touches upon four different components in each situation: motivation, power, knowledge and legitimating, (Ulrich, 2005).

By reflecting on some of the stages of each methodology and by assessing their strengths and weaknesses, we indication that SSM and CSH may complement each other, as they can provide strengths which can equal out some of the weaknesses and threats of the other. For instance, SSM and CSH each offer very useful insights in regard to problem solving, and even though they are both soft approaches to complex situations, they are bound in different paradigms, and different theoretical backgrounds, they both seek to operationalise the participation of stakeholders into improving problematic situations. Also, they both aim at bringing both decision-makers and affected stakeholders into the process using a pragmatic approach.

Although Munro & Mingers (2002) report a reasonable number of cases in which SSM and CSH have been used, a formal framework in which the strengths of these two approaches can be amalgamated have not been reported in the systems literature. According to Mingers & Munro, the use of multi-methodology seems to be common in management science practice even though a theoretical platform when applied is not declared. However, in the case of SSM and CSH, at a conceptual level at least there seems to be a reasonable case for such a combination, recently, Ormerod (2007) in a reply to Ulrich, stated:

*"The ultimate guarantator in the CSH scheme of things is the democracy of citizens. This reliance on democracy rather than principles would seem to be entirely consistent with pragmatism. However, this needs to be worked through. (…). At some point it also needs to be spelt out how CSH can be made to work with particular methodologies such as soft systems methodology and the strategic choice approach"* (Ormerod, 2007, p. 1116).

This paper sets out to fill this gap and proposes a conceptual framework for the use of SSM and CSH in order to obtain improvement to both analytical and critical approach to problem situations. The paper was triggered by these two questions:

- Can CSH enrich the framework of SSM?
- Can CSH and SSM be combined without violating their individual paradigms?

The paper is organised as follows: (1) introduction; (2) the case for the use of multi-methodological approaches in management science practice is outlined; (3) and (4) SSM and CSH are sketched and their main 'limitations' and 'strengths' are discussed arguing for an amalgamation of the two methodologies; (5) based on the previous assessment, the possibilities of combining the two methodologies are discussed and the framework Critical Soft Systems Framework (CSSF) is advanced and discussed in detail. Its main features are described, emphasising the fact that CSH can enriche some of SSM stages; and finally (6) some concussions and perspectives for the potential use of CSSF are suggested.

## 2. Multi-methodology

During the 90s there has been a great debate in the systems community about issues concerning the use of more than one methodology (combinations of them or parts of them) when intervening in complex situations. The general term of multimethodology, Mingers & Brocklesby (1997), Mingers (1997a), Paucar-Caceres (2002) has been coined to group systemic practices that combine and link various methodologies or some stages of two or more methodologies. Mingers (1997a, 1999) takes the view that any intervention should gain

benefits from being approached with a variety of management science methodologies in what he calls 'strong pluralism' arguing that agent(s) (i.e. person(s)) intervening in the situation would benefit, if the intervention is tackled using a 'blend of methodologies'.

In Mingers' view the following arguments favour an application of a multiplicity of methodologies: (1) any situation is in itself so complex that no single methodology can claim to be able to tackle it completely, rather we should pay attention to three aspects involved in any intervention: material, social and personal. Some methodologies will bring more enlightenment to some of the three aspects than others; (2) an intervention is not a discrete event but continuous and therefore some methodologies are more suitable to certain phases of the intervention. We should not disregard the possibility of combining methodological stages, methods or tools from different methodologies serving to different paradigms; and (3) finally there are practical reasons in favour of multiparadigm multimethodology: many systems practitioners have already started to practice it. Mingers provides numerous examples supporting his claim and uses five dimensions to characterise the different types of multi-methodology practice: (a) one/more methodologies; (b) single/multi paradigm; (c) same or different intervention; (d) whole/part methodology; and (e) imperialist/mixed (Mingers, 1997b).

Operating within one paradigm will limit the outcome of information on the problem situation to the particular viewpoint, where it has been conducted. On the other hand, the use of multi-methodology and essentially multi-paradigm multi-methodology demands a wide understanding of both theories, and methods as well as a skilled facilitator. We will argue in some detail in section 5 that CSSF will be a particular case of (b) and (d) that is multi-paradigm and multi-methodology above.

Munro & Mingers (2002) have conducted a survey of the actual use of multi-methdology. Nearly 300 questionnaires were sent to practitioners, 64 were returned. They report that from the survey information was gained on, which methodologies were used as well as information about 'if' and 'how' they were combined. From the analysis, Munro & Mingers state that:

*"(…) although most users of multimethodology are based in a single paradigm, there is a small but significant movement within OR/MS that is both multimethodological and multiparadigmatic"* (Munro & Mingers, 2002, pp. 374-375).

"*(...) that multidisciplinary is the norm within practitioners of multimethodology anyway*", (Munro & Mingers, 2002, p.371).

The survey brought forward that both SSM and CSH were frequently used by practitioners, both as a single method and as part of multi-methdological approach. SSM appeared to be both highly used and known by the questioned. In fact it was the most applied methodology referred to in the survey. On the other hand, fewer knew of or had used CSH, and a large number had never heard of it. However, the survey reported a high success for both SSM and CSH with a mean score of 5.0 and 6.0 respectively (out of 7). Furthermore, it was found that multi-methodology approaches consisting of two or three methods/methodologies were the most common. The report indicates, that SSM and CSH have been used in combination in six cases and in seven cases the two methods were accompanied by a third methodology. Finally, the survey indicates, that SSM is the method most commonly used in combination with others:

*"SSM is distinctive in that it appears to be the predominant methodology used as part of a multimethodology, in combination with other techniques. (…) A variety of exploratory techniques can be used to argument SSM, e.g. cognitive mapping, critical systems heuristics, statistical analysis and scenarios"* (Munro & Mingers, 2002, pp. 374-375).

**3. Soft Systems Methodology (SSM)**

Peter Checkland's Soft Systems Methodology (SSM) is one of the most developed Systems Methodologies in terms of its theoretical premises and philosophical underpinnings. It is also one of the most widely used in the UK and in other parts of the world, see (Mingers & Taylor, 1992), (Ledington & Donaldson, 1997); (Macadam & Packham, 1989); (Macadam et al., 1990) amongst others. During the 1970s, Checkland and his colleagues at Lancaster University questioned the use of hard systems thinking to real-world situations and based on real world action research they teased out a new methodology, that shifted the systemicity from the real world to the process of enquiry itself.

Essentially, SSM articulates a learning process which takes the form of an enquiry process in situations where people are concerned. This process leads to action in a never ending learning cycle: once the action is taken, a new situation with new characteristics arises and the learning process starts again.

The original methodology layout is summarised in Fig 1. This approach to SSM is in general the best known and although Checkland has presented a more flexible way of applying his ideas, in Checkland & Scholes (1990/1999) and Checkland & Poulter (2006), the 7-stage methodology is still an easy way to start using SSM.

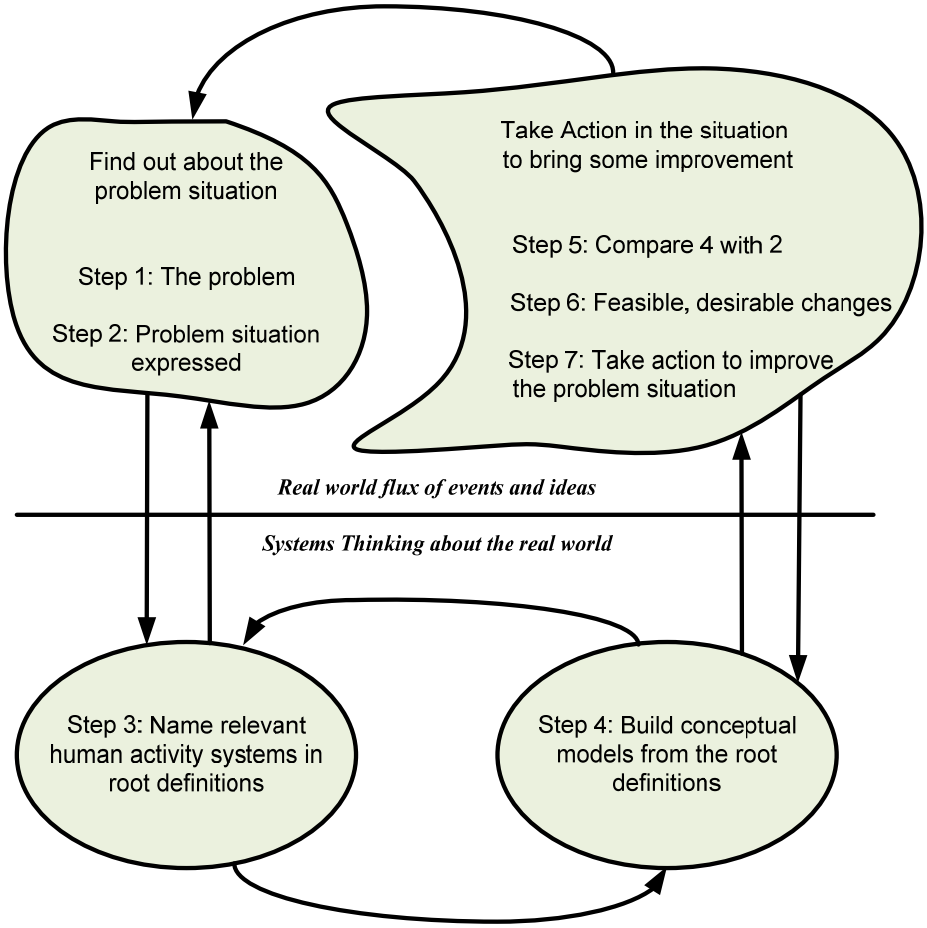


**Figure 19 The Basic Structure of Soft Systems Methodology– SSM, adapted from (Checkland, 1981, p.163).**

The basic structure of SSM rests on the idea, that in order to tackle real-world situations, the 'real-world' should be separated from the 'systems thinking world'. This distinction is crucial for SSM because it assures, that we won't see systems 'out there'; that is in the real world. SSM urges us to consider 'systems' as abstract concepts (preferably, the word 'holons' should be used) which, when used against the real-world, can eventually help to bring some improvements to the situation concerned.

SSM follows an interpretive perspective. This can be summarised as follows: According to Checkland, the real life world is an ever changing flux of events and ideas and 'managing' means reacting to that flux. We perceive and evaluate, take action(s) which itself becomes part of this flux, which lead to next perceptions and evaluations and to more actions and so on. It follows, that SSM assumes that different actors of the situation will evaluate and perceive this flux differently, creating issues that the manager must cope with. Here, SSM offers managers systems ideas as a helpful tool to tackle problematic situations arising from the issues. The

world outside seems highly interconnected forming wholes; therefore it seems that the concept 'system' can help us to cope with the intertwined reality we perceive.

Checkland himself acknowledges, that his methodology fits into an interpretative paradigm, when he states:

*"Social reality is the ever-changing outcome of the social process in which human beings (...) continually negotiate and re-negotiate with others their perceptions and interpretations of the world outside themselves*", (Checkland, 1981/1999, pp. 283-284).

The seven steps of SSM have during 30 years of practise been adjusted into two modes, 'mode 1' and 'mode 2', of the methodology. SSM consists of four main elements: 'find out about the situation', 'design of purposeful activity models', 'ideas for change', and 'take action to improve'. The seven steps shown in Figure 19 are commonly accepted as the 'mode 1' use of the methodology. As the knowledge of and practice with SSM 'mode 1' has increased a 'mode 2' has been developed (Checkland 1993/1999). The process of the 'mode 2' use of SSM is very dynamic as it takes a more autonomous shape. It will never be a flat straight forward process, but an iterative learning cycle. To structure the process of a 'mode 2' use of SSM the model in Figure 20 can serve as a sense making device, (Checkland & Poulter, 2006). How the two modes are formally conducted, will not be further addressed here, but some basic tools of the methodology will be discussed in the following paragraphs. Full accounts of how to conduct SSM can be found in Checkland (1993/1999) and Checkland & Poulter (2006).

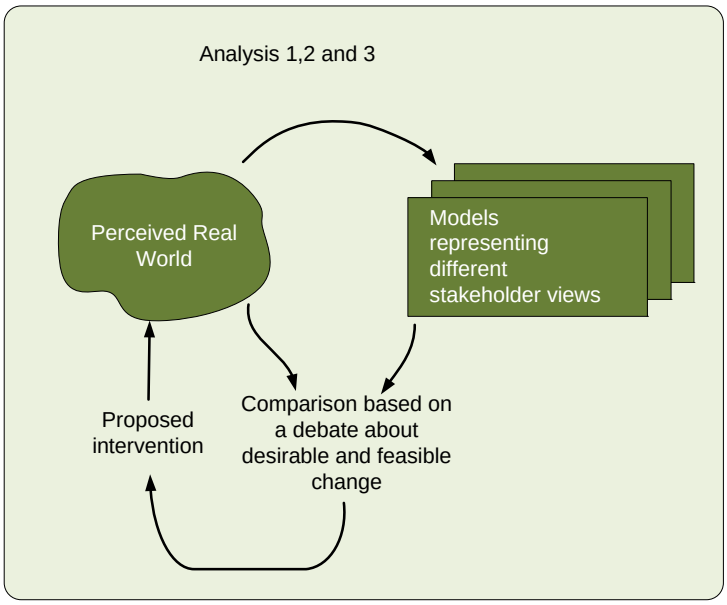


**Figure 20 The learning cycle of Soft Systems Methodology, adapted from (Checkland, 1993/1999, p. A9 & p. A55), is used as a sense making device.**

### 3.1 SSM 'limitations'

SSM limitations have been exposed mainly by (Jackson, 1992, 2003), (Flood & Jackson, 1991), (Mingers, 1984), (Lane & Oliva, 1994), (Paucar-Caceres & Rodriguez-Ulloa, 2005) amongst others. Essentially they argued that because of the interpretive underpinning, SSM is not a 'problem-solving methodology' and that can cause concern and uneasiness amongst practitioners in particular the modelling step, it was found to limit the intervention. SSM according to Lane & Oliva (1994) is a methodology to explore the real world and because its models are not descriptions of the real world (SSM firmly believe that the real world is difficult to grasp) they are not normative; they are 'ideals' or devices which enable structuring of debates.

So, for instance, the first phase of the SSM learning cycle concentrates on 'finding out' about the problem situation. Four methods have proven their worth within this task. These are respectively 'rich pictures' and 'analyses 1-3'. The first use of Rich Pictures were supported by questions that needed to be addressed, these questions were later dropped, Checkland & Poulter (2006). The questions that pointed out the important features of the rich pictures were:

*"What resources are deployed in what operational processes under what planning procedures within what structures, in what environment and wider systems, by whom? How is resources deployment monitored and controlled?"* (Checkland & Poulter, 2006, p.24).

Without the guiding questions it is up to the facilitator and the stakeholders to conduct the rich picture and gain as much information from the 'finding out' phase as possible. This leaves the responsibility of obtaining information with the abilities of the facilitator to shed as much light on the problem situation as possible. If there are no guidelines, there is a risk, that the questions asked will be within only one or a few worldviews and that a "positive atmosphere" will leave out important critical questions, relations and information. The same is the risk of analyses 1-3, as they likewise are highly influenced by the skills and knowledge of the facilitator.

In analysis 1, effort is put into understanding the roles of the involved stakeholders. It is emphasised that one stakeholder or stakeholder group can have more than one role in the problem situation. It is important that, among others, the owner of the problem situation, the client and beneficial and/or, victims are identified. Analysis 2 involves the cultural norms, emotions and culture of the stakeholders of the problem situation. To address these matters and suggest improvements that are 'cultural feasible' a simple model involving the interrelations between roles (both formal and informal), norms and, values has been created. The relations between these three elements of human relations are developing over time and

with changing worldviews, and they are to be seen as dynamic. Analysis 3 takes the 'political' aspect of the situation into consideration, by dealing with the disposition of power, and how to accommodate different interests. Analysis 3 seeks to determine how power is obtained, used, expressed, defended, and passed on, (Checkland & Poulter, 2006). The information that can be obtained from analyses 1-3 is very enlightening when they are conducted. But as for the rich pictures, there are no further guideline on how to obtain the necessary information and critical approach to the answers. It all relies on the skills of the facilitator, and the ability of this person to ask the 'right' questions to the 'right' stakeholders, and to use these to move forward.

Though guaranties cannot be made for asking the 'right' questions and getting the 'right' answers, the four main tools of the 'finding out' phase is setting up good frameworks for this. These are though without guidance towards how to obtain information and equally important how to ensure critical reflection.

In the second phase of the SSM learning cycle, purposeful activity models are designed. These are based on the findings from the 'finding out' phase and denoted in root definitions and further analysed using CATWOE. A CATWOE analysis of the root definition provides information about Customers, Actors, Transformation process, Worldview, Owner and Environment. This information corresponds to some of the findings from analysis 1 in the 'finding out' phase, within in the formulation and worldview of the root definition. The elements of CATWOE can cover a lot of information, and may fail to provide a critical approach, as it sees the problem situation as it is stated through the worldview of the root definition.

Basden & Wood-Harper (2006) indicate that there are some problems associated with the usefulness of CATWOE analysis when dealing with conflict and allude to the call of the very SSM authors to look from 'other systems thinking' to assist SSM these weaknesses:

*"The CATWOE analysis tends to generate insipid proposals and that it gives little help in healing conflict are unlikely to be solved by merely redefining individual elements. To address such problems, Checkland (1981/1999, p. 169) and Checkland & Scholes (1990/1999, p. 156) suggest that SSM may be supplemented by 'other systems thinking'."* (Basden & Wood-Harper, 2006, p.67).

Furthermore the CATWOE analysis has recently been subject to some 're-design', see for instance (Akers-Smith, 2004). These different additions and changes for understanding suggest, that although the CATWOE is useful, it might not be a complete tool for working

with the root definitions. One of several reasons for this could be, that the elements are defined both too broadly and too narrowly at the same time, so that the single elements cannot provide the critical questioning and broad perspective on the given worldview, which is necessary to deal with the problem situation.

It can be argued that these 'limitations' of the methodology are evident, because of the paradigm in which it is embedded. The interpretive paradigm, where SSM is based, is an explorative paradigm, which seeks to bring forward many approaches, worldviews and ideas. This generation of input and knowledge of the situation did not directly encourage a critical approach, but a divergent process, that does not leave out possibilities to understand the given situation.

**4. Critical Systems Heuristics (CSH)**

Critical Systems Heuristics was developed by Werner Ulrich in 1983 to provide a reflective approach to problem solving based on both practical philosophy and systems thinking, (Ulrich, 2005). The framework is based in the emancipatory paradigm and focus upon boundary settings and judgements, (Jackson, 2003). Jackson (2000) describes the emancipatory systems approach as suspicious towards society and current social order, and as trying to reform this in order for it not to benefit from some groups at the expense of others, which then suffers from domination or discrimination. Jackson (2000) furthermore states that emancipation of the oppressed, can and often will benefit the oppressor too.

Without a firm set of boundaries for a given problem situation it becomes nearly impossible to develop a common understanding of the situation, solutions, and plans for the involved stakeholders. Stakeholders are most likely to have very different perceptions of the situation. Boundaries cannot be defined as either right or wrong, but the participants need to agree upon the boundary setting in order for them to deal with the situation. Boundaries should be set through dialog among the involved and affected, (Jackson, 2003).

Boundary critique deals with the concept of "setting the scene" or the boundary setting of the problem situation in question. Setting common boundaries enables a discussion about the given matter and establishes a frame for debate, solutions and plans. The process of boundary critique contains several elements, (Ulrich, 2005):

- Name the preferences of any stakeholder regarding a problem situation or solution proposal
- Analyse the practical and ethical implications of the boundary judgements

- Make alternative reference systems to obtain alternative answers to the boundary questions
- Search for a common understanding of the reference systems among the involved stakeholders
- Challenge the given assumptions using boundary critique in the emancipatory way

On this basis is CSH certainly designed to deal with issues and inequalities addressing the imbalance of power relationships amongst stakeholders. Ulrich and Basden & Wood-Harper observe that:

*"A critical approach does not yield any single right answers either; but it can support processes of reflection and debate about alternative assumptions"* (Ulrich, 2005, p.1),
and that

*"A noted strengths of the Critical approach is its ability to bring power relations and political and economic structures into the debate as the origin of Weltanschauungen,* (Basden & Wood-Harper, 2006, p. 67).

Figure 21 shows the relations between the three elements that according to Ulrich are the essence of boundary setting. These elements form the 'eternal triangle' and should be assed with regard to each other.

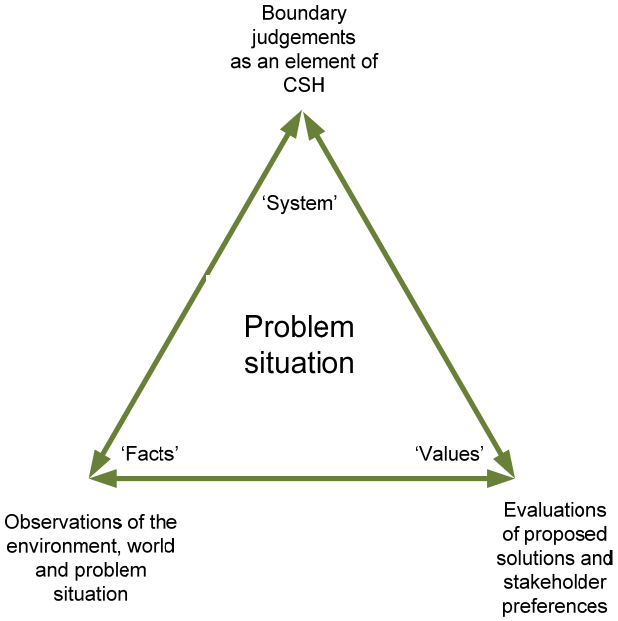


**Figure 21 The 'eternal triangle' of boundary judgements, facts, and values, adapted from (Ulrich, 2005, p. 6)**

These three cornerstones of boundary setting are addressed by the 12 questions in CSH, shown in Table 22. The questions can be asked in both an 'is' and an 'ought to' mode. The 'is' mode helps clarifying the present situation whereas the "ought to" mode develops information about how the situation ideally should be. The difference in between the two modes, addresses the unresolved boundary issues. The two modes can be used separately, but preferably in combination. (Ulrich, 2005).

*"If an intervention design already exists, the 'is' version of the questions can be used (Ulrich, 1987), and the results compared with answers to the 'ought' versions. Again a debate should ensue. The Process should be exploratory and creative. In the end all the questions have to be answered, decisions have to be taken, but these will have been better informed by the (critical) debate" (Ormerod, 2007, p. 1117).*

| No. | Boundary issues | | Questions |
|---|---|---|---|
| 1 | Sources of motivation | Those involved | Who 'is' ('ought to be') the **client** or beneficiary? |
| 2 | | | What 'is' ('ought to be') the **purpose**? |
| 3 | | | What 'is' ('ought to be') the **measure of improvement** or measure of success? |
| 4 | Sources of power | | Who 'is' ('ought to be') the **decision-maker**? |
| 5 | | | What **resources** and other conditions of success 'are' ('ought to be') controlled by the decision-maker? |
| 6 | | | What conditions of success 'are' ('ought to be') part of the **decision environment**? |
| 7 | Sources of knowledge | | Who 'is' ('ought to be') considered a **professional** or further **expert**? |
| 8 | | | What kind **of expertise** 'is' ('ought to be') consulted? |
| 9 | | | What or who 'is' ('ought to be') assumed to be **guarantor** of success? |
| 10 | Sources of legitimation | Those affected | Who 'is' ('ought to be') **witness** to the interests of those affected but not involved? |
| 11 | | | What secures ('ought to secure') the **emancipation** of those affected from the premises and promises of those involved? |
| 12 | | | What **worldview** 'is' ('ought to be') determining? |

**Table 22 Boundary issues and the 12 questions, adapted from (Ulrich, 2005, pp. 10-11).**

### 4.1 CSH limitations and contributions to enrich SSM

In Ulrich (2005) boundary critique is referred to as either a reflective or an emacipatory practice. These describe respectively a self-critical and not self-critical process, (Ulrich, 2005). Jackson (2000) states that CHS is a systems based approach not only leading towards 'what to do' but helping in finding out 'how we (ought) to do it' and that the questions were designed to be practically oriented. Ormerod (2007) concludes, that the 12 questions were not designed to be objectively answered but proposed to provide a basis for debate and Ulrich states that boundary critique should be combined with problem structuring and problem solving methods.

*"(…) boundary critique is not a self-contained approach but is more useful in combination with other approaches to problem structuring and problem-solving" (Ulrich, 2005, p. 5),*

and

"*In essence, CSH identifies the key ethical issue in a professional inquiry (or intervention or engagement) as the choice of who is to be involved in the discussion and in what role (expert, citizen, decision maker, etc). These choices should be debated in the particular instance. The method does not offer fixed ethical principles to guide the choices but it does draw attention to the affected but uninvolved" (Ormerod, 2007, p. 1116).*

This is supported by statements from Flood & Jackson, who in Jackson (2003) are referred to have pointed out, that CSH is not a mature methodology and that it lacks supportive tools and techniques as the ones found in SSM.

These statements support the argument towards a combined used of SSM and CSH. We argue that SSM can serve as the problem solving approach and CSH will provide the means for critical reflection. This argument is clearly supprted by Jackson (2003), where it is suggested, that the 12 questions can be extracted from Ulrichs over all approach and used along other methodologies. In Jackson (2003) there is furthermore referred to Ulrich that:

*" (…) if we wish to understand and improve social reality, we must add an additional dimension of 'purposefulness' and design social systems to become purposeful systems" (Jackson, 2003, p. 217).*

This approach can be related to the development of purposeful models with the second phase of SSM. And CSH has other similarities with SSM and strengths to offer. There can be drawn similarities between CATWOE and the 12 questions of CSH. Furthermore, CSH possess abilities regarding boundary setting, boundary critique and it can strengthen emancipation in a way, that are not explained in SSM.

## 5. Critical Soft Systems Methodology: a systemic framework combining soft systems methodology (SSM) and critical system heuristics (CSH)

In the previous sections we have indicated, that some benefits could be obtained from combining SSM and CSH. In this section the general framework is outlined and described in more detail.

Combination of SSM and CSH will join two methods stemming from respectively the interpretive and the emancipatory paradigm. These are both placed in the soft approach to complex problem situations, but will, if combined result in a multi-paradigm multi-methodology approach. Figure 22 shows an overview of approaches to methodology and paradigm combination. The seven combinations each present an approach to the use of methodologies either in isolation or in combination. The figure shows how methods can be combined either as a whole or as parts combining one or more paradigms.

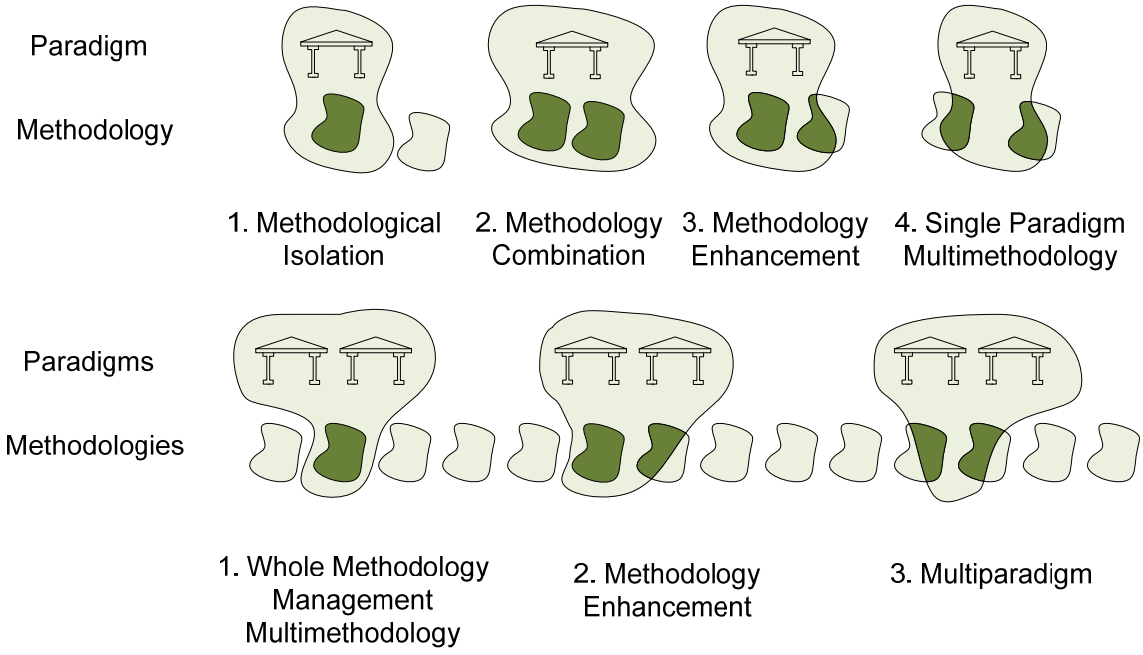


**Figure 22. Relations between paradigm(s) and methodology(ies), from (Paucar-Caceres, 2000) .**

The proposed combination of SSM and CSH will draw upon two paradigms and two whole methodologies. For the proposed approach, SSM will serve as the primary framework and CSH will be used to enrich steps within the SSM process. Sketch No. 2 in the lower row illustrates a combination close to the proposed. As the proposed approach contains two whole methodologies within two paradigms, an adjustment of the sketches is needed. Figure 23, presents a sketch illustrating the exact methodological and paradigm proposal and illustrates, how the proposed Critical Soft Systems Framework (CSSF) approach aims at becoming one approach based on two paradigms, where two whole methodologies from to paradigms are combined.

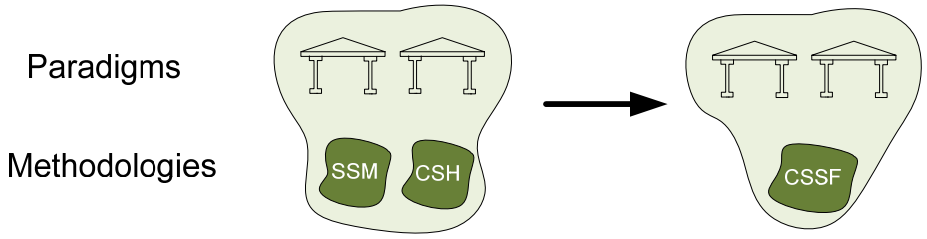


**Figure 23 Illustration of the combined used of SSM and CSH within the frame of the two individual paradigms.**

The combination of elements from the interpretive and the emancipatory paradigm will provide an approach, which is both exploring and critical at the same time. The two paradigms have been developed one after the other and they are both results of different approaches to problem solving. They both developed as a reaction to the existing paradigms and especially the hard approach to problem solving. Petkov et al. (2006) have shown that methods can be combined in a multi-methodological process. This approach is based on the ideas of Mingers and Jackson. Petkov et al. (2006), has, based on three case studies concluded, that methods based on different paradigms can be mixed, but state, that further practical work is needed in this field. This corresponds with the practical findings of Munro & Mingers (2002).

The proposed CSSF approach is based on these two different theoretical foundations of the interpretive and emancipatory paradigm. The interpretive approach to problem solving applies pluralism to the problem situation whereas the emancipatory approach empower the 'victims' of the problem situation and provide pragmatic pluralism to deal with the diversity, (Jackson, 2003). The paradigms each provide part of the theoretical foundation for the necessary actions to deal with a complex problem situation. They respectively bring forward important issues. The interpretive paradigm provides the broad view and the foundation of pluralistic multi-methodological approach, whereas the emacipatory paradigm contributes with critical reflection. We argue, that these two paradigms can be combined within the CSSF approach as they serve to clarify different aspects within the problem situation. The two paradigms enable CSSF to deal with developing problem situations as complex situations can be dynamic and thereby change along with the time.

### 5.1 Combination of the methodologies and the derived benefits

Bringing SSM and CSH into a combined use bring forward questions such as "what do the methods have in common?" and "how can they enrich each other?". SSM and CSH were briefly presented in section 3 and 4, and within these sections strengths and weaknesses of the methodologies where brought forward.

SSM was presented as a 'mature methodology', which is often applied and has proved its worth as a problem solving method. This explorative method provides a complete frame for analysis that can deal with much information and stakeholder inputs. The method consists of a number of elements that requires training for proper use, time, facilitating skills and openness among those involved in the process. If the facilitator has not got the necessary routine and skills, stronger participants might oppress weaker. SSM contains elements that can seem 'naturally' in an analysis – such as enquire about relations and information, but in SSM they are an organised process. This approach might be difficult for 'hard thinkers' as it is not a formula but a learning cycle developing with the problem situation. A number of questions can be raised regarding the amount of information it provides: "is this enough and the requested?", "who and how many should be included?", and "how to ensure to get hold of the right persons?". A series of analysis tools are outlined, among these analyses 1-3, rich pictures and CATWOE, but there is no firm guidance on how to conduct these and how to handle the obtained information in a reflective way. It could furthermore be argued, that a critical reflection is missing. SSM is likely to be combined with other methods, both hard and soft, and in this essence it is well suited for multi-methodology.

CSH was presented as easy to access, as it provides a series of concrete questions on both the present and the desired situation. The questions provide critical information and reflection, but afterwards the user needs to figure out what to do by themselves. There might be a risk of being 'locked' to the 12 questions. CSH does as well provide good possibilities for combination with both hard and soft methods. As SSM it is well suited to take part in a multi-methodology approach, and does provide a frame for some of the questions we naturally tend to ask. In this frame the questions are designed to apply a critical approach to beneficiaries, victims, power, and legitimation of the problem situation. Though the 12 question cover a wide range of the critical approach, important information which is not covered by these might be left out, if a broader prospective is not taken. Stakeholders might be 'locked' by the questions and 'forget' about other areas. It is equally important to obtain openness so information is not kept away from the analysis. The questions do not provide firm guidance on how to deal with the interrelations between the stakeholders and various worldviews of the problem situation.

The 'is' mode and the 'ought to' mode of CSH provide information about the problem situation in question with regard to how the situation is and how it ought to be. These two parts of the analysis can be compared to respectively the rich picture, analyses 1-3 and the root definitions of SSM. The 'is' mode of CSH explains the situation in terms of words – just like the rich picture and analyses 1-3 describes the existing situation in terms of pictures, words and relations. The 'ought to' mode brings forward information on how the situation ought to

be, as do the root definitions and conceptual models in SSM. The ‘is’ mode and the rich picture is part of the real world and the ‘ought to’ mode and root definitions is part of systems thinking about the real world, see Figure 24.

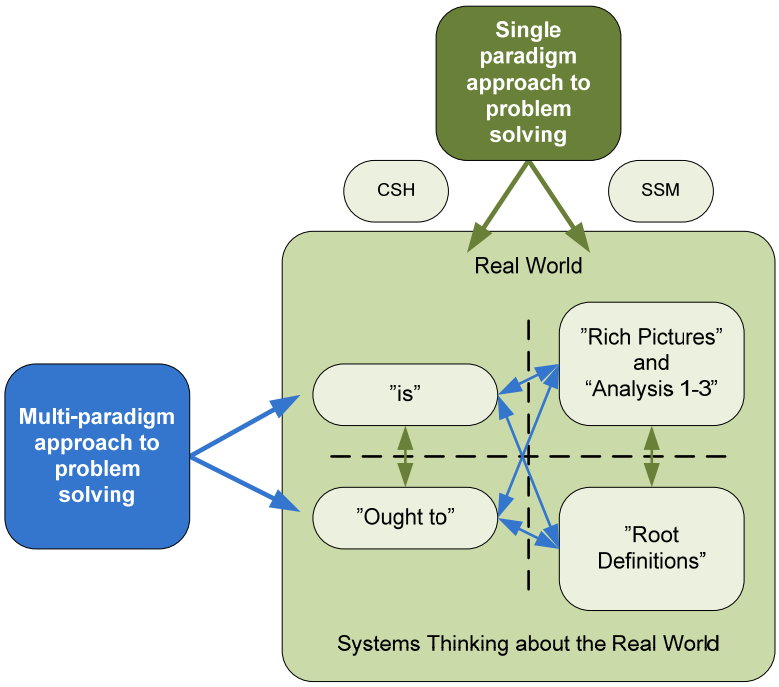


**Figure 24 Relations between the problem situation and elements of SSM and CSH in respectively the real world and systems thinking about the Real World**

Figure 24 illustrates how the two methodologies have similar tools for dealing with the problem situation as it is in the ‘real world’ and how it ought to be in the ‘systems thinking about the real world’. Two approaches are pointed out. The green approach to problem solving (the vertical arrows) works within a single paradigm with a single method whereas the blue approach to problem solving (horizontal arrows) deals with a multi-paradigm approach. The vertical approach deals with respectively SSM or CSH and the horizontal approach combines the two methodologies as in the CSSF approach. The two approaches in Figure 24 furthermore illustrate the similarities of the approaches but open up for mix of the tools on order to cover both interpretive and emancipatory matters of concern.

In section 3.1 it was found that the rich pictures and analyses 1-3 faced limitations in the finding out phase as the approaches to finding out did not necessarily involve critical reflection and emancipation of any suppressed stakeholders. In section 4 it is pointed out that CSH serves to empower the suppressed and provide 12 questions for critical reflection on both the present and the preferred situation. The ‘is’ mode questions consider the existing situation in the ‘real world’ and can if applied in the finding out phase serve as a guideline for

facilitators to present critical reflection on the information, which is brought forward about the existing situation. Implementation of the 'is' mode questions can provide assistance for the facilitator in both conduct of the rich pictures and analyses 1-3. The 'ought to' mode questions can be used in the development of the root definitions. This development takes place in 'systems thinking about the real world' and the 'ought to' questions can here provide information about the desired change seen from the different worldviews of all the involved stakeholders. In the 'systems thinking about the real world' as well as in the 'real world' the 12 questions provide a frame for critical reflection of the findings conducted within the SSM frame.

Another similarity between SSM and CSH is found in the formulation of the 12 questions within CSH and the CATWOE analysis of SSM. The 12 questions of CSH provide critical reflection upon all the involved parties, and properties of the situation. Equally CATWOE contributes with information on the implicated parties. Both tools deal with the different roles of the stakeholders and their interrelations and the direct similarities between the two sets of questions are illustrated in Figure 25. From this figure it can be seen how the CATWOE elements relates to the main objectives of each of the 12 questions in CSH. Furthermore, it can be seen, that some of the CATWOE elements cover more than one element within the frame of the 12 CSH questions, and there are as well elements of CSH, which do not have a corresponding part in CATWOE. The elements of CSH without a corresponding CATWOE element are respectively found in the 'knowledge' and 'legetimation' components and regards the 'guarantator', 'witness' and 'emancipation'. The areas are highlighted with dark green in Figure 25 and the lines show the relation between elements of the two respective approaches. The number in front of the CSH elements refers to the question number. Here they have been split up in order to clarify the relations to CATWOE.

The elements of CSH which does not have a direct correspondent in CATWOE indicates areas of reflection which are not directly addressed by the SSM tool. It is equally important, that two of the elements of CATWOE correspond with more than one element of CSH. This indicates, that the roles of the different stakeholders are more specific addressed by the 12 questions of CSH than by CATWOE and that CSH therefore can give a more in-depth clarification of the different stakeholderroles and their individual relationships.

Based on the similarities within the two methodological approaches to problem solving, some relationship between the methodologies can be established. The two modes of CSH can as explained above be used to enrich the 'finding out' phase and in the making of the root definitions. Seen in relation to the learning cycle of SSM, mode 2 SSM, this could be pictured as in Figure 26.

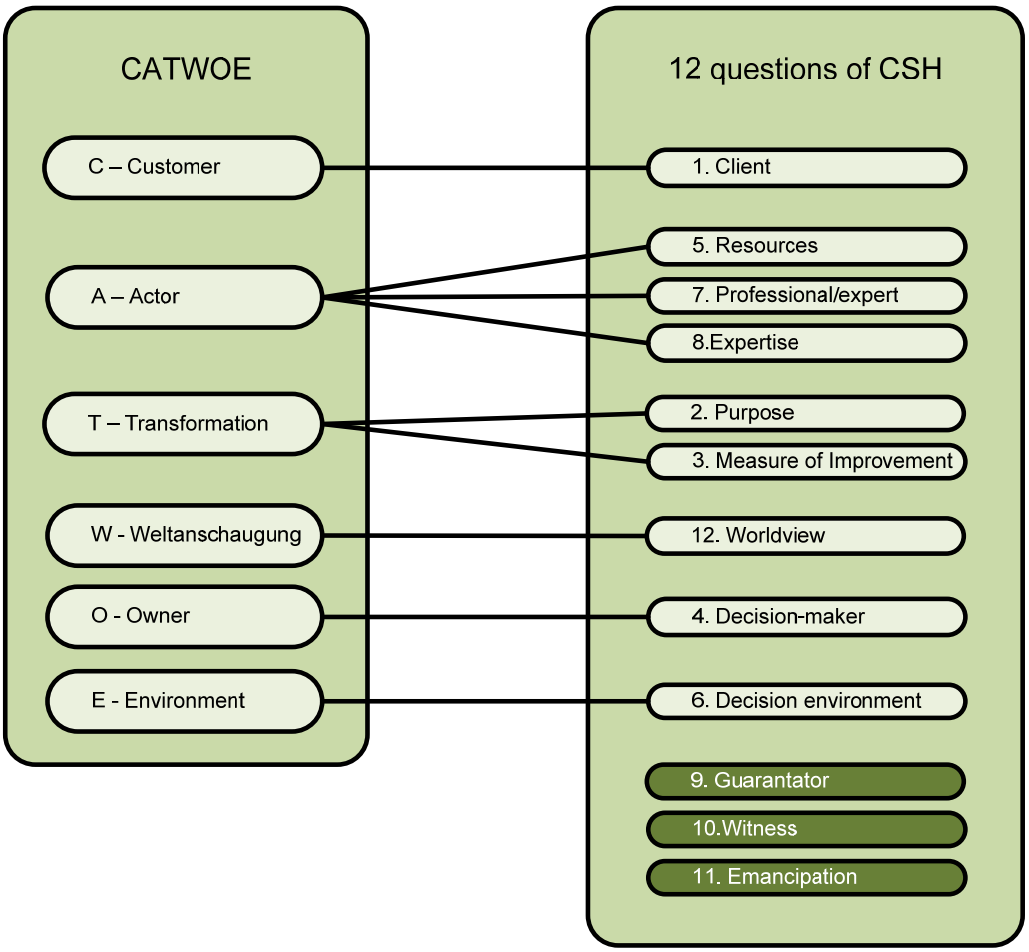


**Figure 25 Comparison of the question issues of CATWOE and the 12 questions of CSH**

Figure 26 illustrates the CSSF approach where the 'is' and the 'ought to' questions are introduced in SSM learning cycle. From Figure 26 it can be seen, that CSH might be able to participate in and enrich the "finding out" and "make purposeful activity models" phases. From this it can be seen how the enrichment takes part in both the 'real world' and in the 'systems thinking about the real world'. Furthermore the implementation of CSH in SSM can enable a larger focus on critical reflection and boundary setting. SSM does not have a specific tool for boundary setting. Analyses 1-3 can be developed in this way, but the fundamental thoughts provide this in its definitions. The three corners of the 'eternal triangle' in Figure 21 indicate the importance of the relations between observations ('facts'), boundary judgements ('system'), and evaluation ('values').

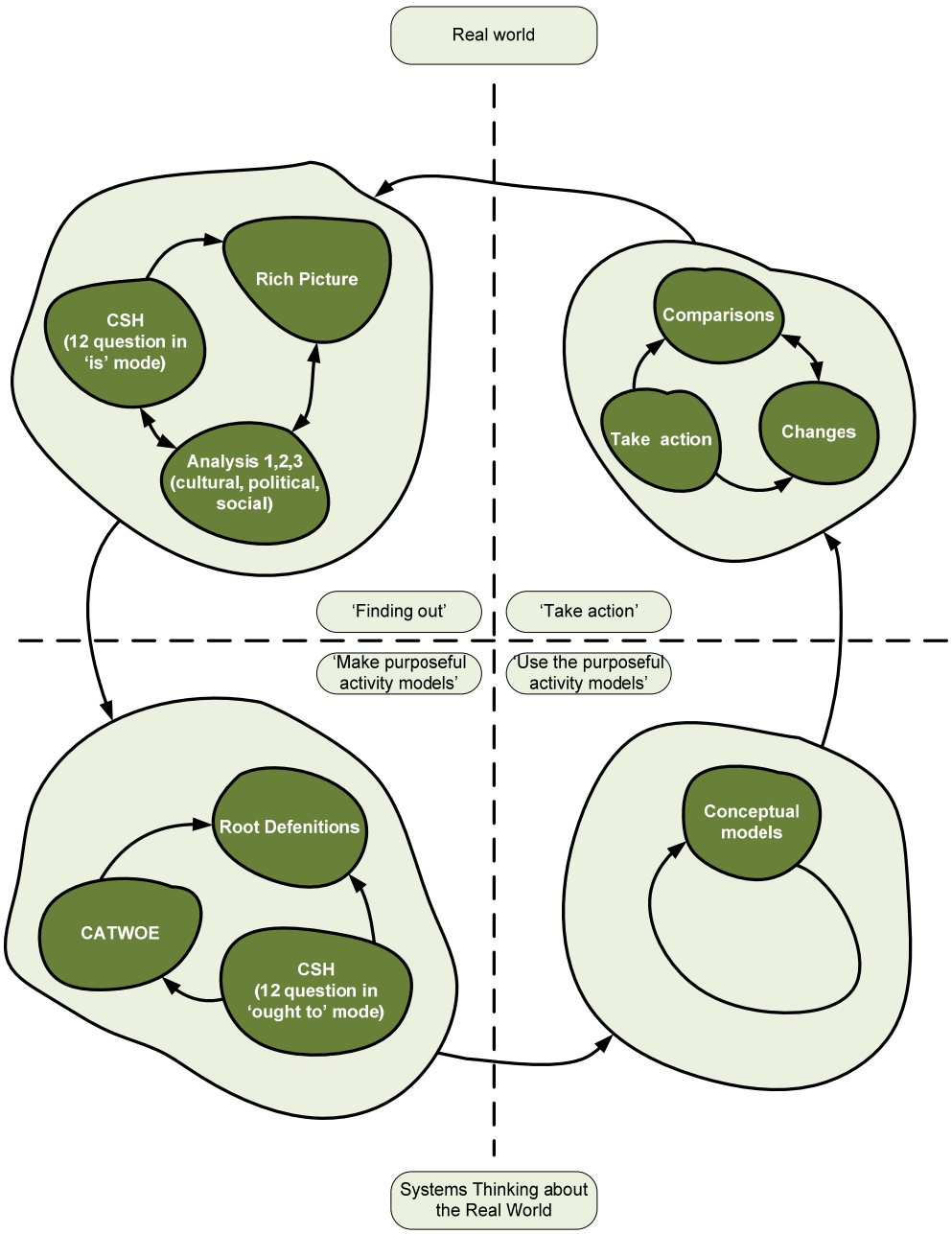


**Figure 26 Outline of the learning cycle of the combined CSH and SSM approach in SSM mode 2 to the CSSF approach**

## 6. Conclusions and perspectives

Multi-methodological approaches seem to be common in management science and systems practice. Although Munro & Mingers (2002) reported the use of SSM and CSH in combination, details of the papers or cases and the conceptual framework used in each of the seven cases, are not indicated in their survey. One has to assume that the two methodologies were used in combination of some sort but without declaring a theoretical platform. This paper

has proposed a systemic conceptual framework in which these two methodologies coming from two different paradigms (interpretative and emancipatory) can be combined.

The proposed framework called Critical Soft Systems Framework (CSSF) uses the strengths of SSM and CSH. The proposed combination is seen as a mutual enrichment of the two methodologies. Combination of an interpretive and an emancipatory method provides a broad framework to deal with problematic situations. A wide range of inputs are sought and all of these and their relations are subject to critical reflection. The use of the two paradigms in combination outlines an approach based on pluralistic thoughts of multi-paradigm multi-methodology. Even though the methods stem from two different paradigms, the proposed outline is said to be suitable as it does not violate the theoretical background of the paradigms but combine the two approaches to problem solving in one method. The interpretive and emancipatory paradigms are both situated within the soft approach but have different aims and tools. Through the analysis of respectively SSM and CSH it has been shown that they both are suited to be part of a multi-methodology strategy. It has furthermore been shown that the two methodologies have several similarities. The similarities are found in respectively the 'finding out' phase of SSM and the 'is mode' of CSH and in the "modelling phase" of SSM and the 'ought to' mode of CSH. Furthermore it was found that there are several similarities between CATWOE and the aim of the 12 questions. The differences between these two tools are found on the level of detail in the questions. CATWOE considers some important stakeholder roles and factors related to the problem situation. These are mentioned in the six parts of the acronym and the user of the methodology must then determine if some stakeholders have more than one role. The questions of CSH are more specific and reflective in their formulation and will define several different roles of the stakeholders involved with the problem situation.

Critical Soft Systems Framework (CSSF) can provide practitioners with the benefits from two different theoretical backgrounds. This will enable a better understanding of the problem situation and facilitate the work with it and the better of the two paradigms will be gained without loss of either wide frame of interpretative paradigm and the critical reflection and boundary setting of the emancipatory paradigm. We believe that the framework will be suited for all kinds of complex problem situations. We hope that the framework proposed here has shed some light and encouraged these applications to continue and encourage discussion about how CSH and SSM can be combined and formally organised in a systemic framework.

CSSF has not been used and tested yet. The authors are working for further adjustments to the framework and at the same time they have started searching for applications within the area of sustainable transport planning. We do not claim that the proposed framework is free of

improvements, thus comments and criticisms from OR/MS and systems academics and practitioners are welcome.

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## 4.6 Overview of paper 3

*Decision Simulation Technique (DST) as a scanning tool for exploring and explicating sustainability issues in transport decision making*

| | |
|---|---|
| Title: | Decision Simulation Technique (DST) as a scanning tool for exploring and explicating sustainability issues in transport decision making |
| Author(s): | Jeppesen, S. L. |
| Presented: | ISSS2009, 53rd Meeting of The International Society for the Systems Sciences, University of Queensland, Brisbane, Australia, July 12-17, 2009, Making Liveable, Sustainable Systems Unremarkable, Hosted by The University of Queensland and the School of Integrative Systems, Brisbane, Australia, and The Australia New Zealand Systems Group (ANZSYS) |
| Published: | Conference proceedings of ISSS 2009 |

**Paper description**

This paper describes a simulation tool named Decision Simulation Technique (DST) which can be conducted by a single planner on an early planning stage. DST can be used to scan a set of alternatives and to explicate the concept of sustainability within the transport planning process. A so-called advocate can represent a specific strategy developed upon a set of predefined key values, for example a strategy concerning sustainability. The proposed DST consists of three modules comprising the decision problem, the stakeholder analysis and the preference analysis, see Figure 27. The three modules draw on soft methods applied in a semi-soft way and hard methods, respectively.

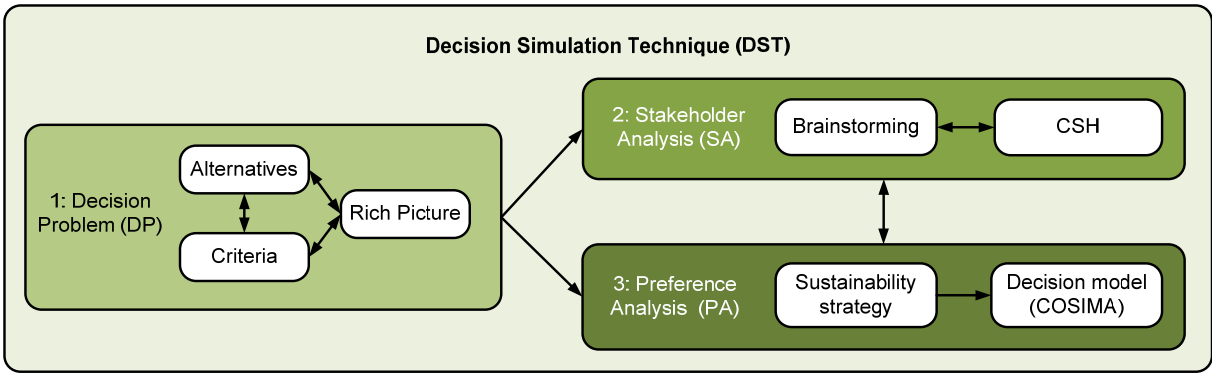


**Figure 27 Overview of the content of the three modules of DST, adapted from (Jeppesen, 2009a)**

In the paper a sustainability strategy is applied to a case study concerning high speed railroad development, with four alternatives (red, green, blue short, and blue long) and eight criteria given by an EIA report. To illustrate how the DST can be used to explicate strategies other than sustainability, an economic strategy is also demonstrated in the case.

**Main findings**

Application of the two strategies resulted in very different rankings of the alternatives under each strategy, see Table 23, thus leading to very different recommendations as concerns which alternative to be seen as the most attractive. Note that part of the two strategies is the different values of the MCA-%, see Table 24.

| Criteria ranking | Sustainability strategy | Economic strategy |
|---|---|---|
| 1 | Natural environment | Natural resources |
| 2 | Cultural environment | Health |
| 3 | Recreation and outdoor life | Natural environment |
| 4 | Natural resources | Cultural environment |
| 5 | City and scenery impression | City and scenery impression |
| 6 | Health | Recreation and outdoor life |

**Table 23 Overview of the criteria ranking in the sustainability and the economic strategies applied in the DST, respectively, adapted from (Jeppesen, 2009a).**

| MCA-% | Sustainability strategy | Economic strategy |
|---|---|---|
| 10 | Red | **Red** |
| 30 | Blue-long | Blue short |
| 50 | **Blue long** | Blue short/long |

**Table 24 Results of the sustainability and the economic strategies, respectively, with regard to different values of the MCA-%. The bold result indicates the recommendation of the DST based on each strategy, adapted from (Jeppesen, 2009a).**

DST proved to be very useful in the pre-planning phase as it can explicate a sustainability strategy by using inputs from a simulated sustainability advocate, who is active throughout the whole process. With DST a single analyst can provide input to the planning process and help to rule out alternatives at an early stage if they do not become attractive under a chosen strategy. Preliminary examination can thereby help to identify the most relevant alternatives for the following participatory group process. Explication of sustainability in transport planning through a sustainability advocate by the use of DST can help to make the concept of sustainability operational. This is considered as one of the major findings of this PhD study.

## 4.7 Paper 3 Decision Simulation Technique (DST)

**Decision Simulation Technique (DST) as a scanning tool for exploring and explicating sustainability issues in transport decision making**

*Presented at ISSS 2009, Brisbane, Australia*
*Published in the proceedings of ISSS 2009*

Sara Lise Jeppesen, DTU Transport, Technical University of Denmark

**Abstract**
This paper places focus on explicit consideration of sustainability issues in transport decision making by presenting and using a developed "Decision Simulation Technique" (DST). This technique can be used by an analyst to 'scan' a transport planning problem with regard to what in DST terms is called a sustainability strategy. This scanning can serve the purpose of informing a group of decision makers before they actually have to deal with, for example, the choice among a number of alternatives that have all been formulated as being relevant. The main focus of the paper is to illustrate how the DST can indicate which one from the set of alternatives will in fact be the 'best' seen from the viewpoint of a sustainability strategy, before they are all scrutinised by the decision makers. The paper consists of three parts. The first part describes the various concepts and elements of the DST together with the principal steps that have to be followed when applying it on a concrete case. In the second part the potential of the DST is demonstrated by its use within an ongoing study. Thus the DST is applied on a new rail investment study on a section with four alternatives being part of a proposed new high speed rail line in Southern Sweden. The third part of the paper is concerned with a principal discussion of incorporation of sustainability in transport planning. It is argued that 'explicating'-techniques such as the DST compared to more traditional ways of doing this – here denominated implicit consideration of sustainability – can be useful for many different planning problems where the treated rail case is just one example. Finally, the paper offers some conclusions and a perspective on the future use and development of the DST.

**Keywords:** Sustainability, decision support, simulation of preferences, semi-soft methods, decision simulation technique (DST).

## 1. Introduction

This paper introduces a scanning tool named Decision Simulation Technique (DST), which can be used by planners and decision makers to simulate a decision process before the actual decision making process begins. The DST is intended to be a pre-decision making tool, conducted by a single analyst, providing information about which alternative that may be the most attractive one under an explicit sustainability strategy. The DST can indicate if some alternatives can be ruled out before the actual decision making process starts. The simulation process is based on information about identified and relevant evaluation criteria and the associated stakeholders' viewpoints are perceived as contenders to the explicit sustainability strategy developed in DST. Simulation of the decision process at the early stages of the planning process provides planners and decision makers with an opportunity to test alternatives against a specific sustainability viewpoint before the actual decision making process begins. Taking a specific sustainability strategy into consideration at an early stage allows the decision maker to conduct a pre-decision making screening of which alternatives that would be attractive under a sustainability viewpoint, the so-called sustainability strategy. This means that planners and decision makers can gain knowledge about which alternatives are of interest to bring forward for the final planning process, public hearings and decision making.

In this context the concept of sustainability is regarded as based on the following key values: long term perspective in the planning, consideration of assets which cannot be restored (e.g. landscape, and cultural heritage), and consideration of impacts on all stakeholders and criteria (Jeppesen & Pedersen, 2005). The application of sustainability viewpoints is sensitive towards the decision making environment. A sustainability strategy is often less convenient and more expensive in the short-term perspective, but more favourable in the long-term perspective. Test of alternatives against a mindset built on a sustainability approach is often left out as the main stakeholders with regard to these viewpoints are grassroots which may not be represented in the final decision making.

In the traditional transport planning sustainability viewpoints are often seen as an implicit part of the decision process. They are put forward in small incoherent parts by all or by a few dedicated participants (e.g. grassroots) who might also have other viewpoints to advocate for. The sustainability viewpoints can also be implicitly represented on paper by the Environmental Impact Assessment (EIA). Commonly the concept of sustainability may be mentioned frequently, but in an implicit structure it may not influence the decision making. The proposed DST can remedy this by being a kind of sustainability 'advocate' designed to represent the sustainability viewpoints. Such explication of sustainability viewpoints can be useful both at the early stages and towards the end of the decision process.

## 2. Decision Simulation Technique

The Decision Simulation Technique is designed to deal with complex transport planning situations. It can help to explicate the concept of sustainability and deal with the complexity related to implementation of the concept in transport planning. A systemic approach to decision making holds several advantages when the decision problem in question is said to be complex (Leleur, 2008). The DST is therefore based on a systemic approach to planning put into practice using a multi-methodology approach to decision making. The multi-methodology approach enables the use of more than one methodology and it furthermore allows a mix of methods from different paradigms and with different aims, see among others (Mingers & Gill, 1997). By using a multi-methodology approach to decision making it has been possible to select the methodologies and tools which are thought most helpful in a scanning process and as tools for making sustainability choices explicit. The DST consists of a combination of both soft and hard methods, which will each provide the simulation technique with problem solving and appraisal qualities. The soft methods are applied in a so-called semi-soft way. The basic principle of such application is that the methods are only used by the analyst performing the scanning. This means that during the application there is no direct stakeholder participation. The different stakeholders and their probable preferences are then simulated by the informed analyst. Application of soft methods in a semi-soft way has been proven a possible approach by Jeppesen et al. (2008) and allows planners and decision makers to gain important information from participatory methods with a minimum use of time and resources. Such applications of the traditional soft methods are chosen, as the DST is supposed to be used as an initial scanning providing planners and decision makers with information about the alternatives that could be of interest for the subsequent appraisal and decision making process. In the DST no final decision is to be made, but initial information is gained for the 'real' planning and decision making process.

The Decision Simulation Technique consists of three interrelated modules, see Figure 28. The three DST modules represent the Decision Problem (DP), a Stakeholder Analysis (SA) and a Preference Analysis (PA), respectively. The modules considering the decision problem and the stakeholder analysis are solely based on soft methods. The third module regarding the preference analysis draws on both soft and hard methods. The general steps within the three modules of the DST are described further in (Jeppesen, 2009).

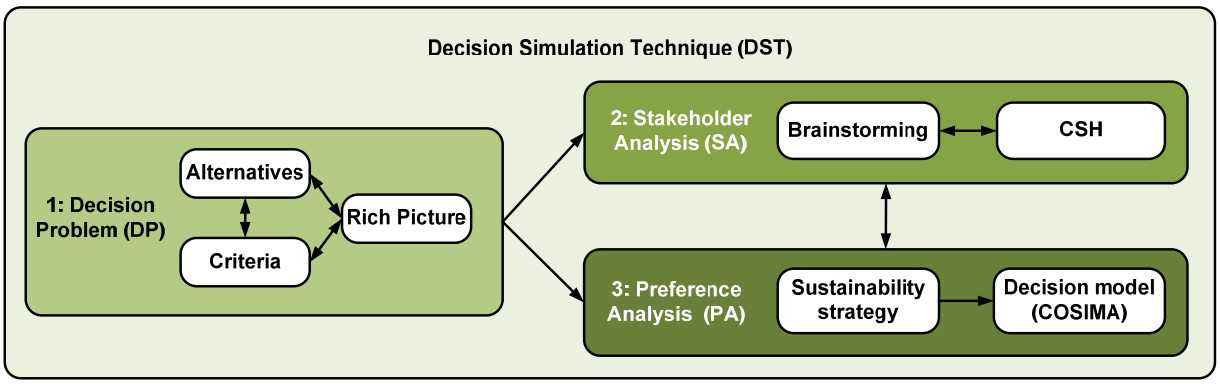


**Figure 28 Overview of the methodologies and relations forming the Decision Simulation Technique (DST)**

## 2.1 Module 1 – Decision Problem

The first module considers the Decision Problem (DP). It regards the properties of the decision problem such as the alternatives and the criteria under which they should be evaluated. This information is sometimes given, but can be determined as a part of the DST using a 'series of brainstorms' and all available material regarding the decision problem. The first module concerns the understanding of the decision problem using Rich Pictures (RP). RPs were developed as a tool for the 'finding out about the problem situation' phase in Soft Systems Methodology (SSM). The concept of SSM will not be explained further as only the RP tool will be used. For information on SSM, (Checkland, 1993/1999) and (Checkland & Poulter, 2006) can be consulted.

RPs can be used to interpret, describe and structure a problem situation, not in sentences alone, but by simple drawings which can be accompanied by essential words and sentences. This technique allows for very difficult situations to be summarised and communicated by a single piece of paper. The technique is a very useful tool for describing and communicating relations between the implicated stakeholders and their different views. A RP can help to provide in-depth understanding of different aspects of a problem situation regarding structure, process and climate. An RP is a snapshot of the problem situation at the given time and thus not a static component. RP can and must be conducted throughout the whole intervention due to the dynamic complexity of the problem situation (Checkland & Poulter, 2006) and (Leleur, 2008).

RPs can be useful in two ways for the DST. If the alternatives and the criteria are given in advance, RPs can be used to communicate the different properties of the problem situation. Pros and cons of the alternatives can be brought forward, whereby some stakeholders might be framed for further analysis by module 2. If the alternatives and criteria are not given, an RP can be used as inspiration for the brainstorming process used to define them.

Alternatives, criteria and RPs are interconnected by double-headed arrows indicating shifting information, influences and relations due to all three elements. Module 1 relates to both modules 2 and 3 as it serves as information feeder, see Figure 28.

### 2.2 Module 2 – Stakeholder Analysis

The second module concerns the Stakeholder Analysis (SA) and depends on brainstorming and Critical Systems Heuristics (CSH) which, indicated by the double-headed arrow, are used to inform each other, see Figure 28. Brainstorming for stakeholders is based on the understanding of the problem situation gained in module 1 and developed from the accessible information regarding the decision problem. CSH, initially developed to assist planners and citizens with social planning, is in the DST used to develop the brainstorming both in terms of understanding the present and the desired situation. CSH consists of 12 questions which can be asked both in 'is' and in an 'ought to' mode, helping to understand which actors are involved or not, and what their roles, knowledge and relation to the decision making are. CSH is developed upon the theory of critical reflection in order to understand the situation, improve planning and emancipate affected stakeholders. CSH will not be further described here but (Ulrich, 1983) and (Ulrich, 2005) can be consulted for further information.

Using CSH as part of the SA analysis in the DST is useful as it can provide the scanning with insides regarding possible stakeholders, their roles and viewpoints. The most important benefit from CSH in relation to DST is the opportunity to get to know if there is a difference in who are actually considered as stakeholders and who ought to be. The information from the stakeholder analysis is used to develop and shape the sustainability strategy which is applied in the third module.

### 2.3 Module 3 – Preference Analysis

The third module concerns a preference analysis (PA) performed to explore the sustainability strategy, which is carried out, among other things, by using an appropriate decision model. The third module is developed based on the information from module 1 and an interaction with module 2, see Figure 28. Before the COSIMA decision model can be applied the sustainability strategy has to be defined. Definition of the sustainability strategy is of vital importance for the DST's ability to explicate the concept of sustainability in the scanning process.

The sustainability strategy is developed for each individual decision problem and builds upon the stakeholder viewpoints gained from the SA in module 2. Development of the sustainability strategy is based on the key values and designed by the analyst performing the DST.

The PA is based on the COSIMA decision model. It combines the information obtained in modules 1 and 2 with the sustainability strategy set out in module 3. The COSIMA decision model consists of a cost benefit analysis (CBA) and multi-criteria analysis (MCA). CBA and MCA are applied in a joint approach, enabling them to be combined into a Total Rate of Return (TRR), which is the model output indicating the attractiveness of an alternative. The technical note at the end of this paper gives the details on the technical aspects of the COSIMA decision model, but the main principles can be outlined by using the following case.

## 3. The case of Ostlänken from Bäckeby to Norrköping

The planning of a new rail connection in Sweden is used to present the DST. The part section running from Norrköping to Bäckeby is part of a larger railway project named Östlänken. Ostlänken is a rail connection between Linköping and Järna in Sweden and is one part section of a large rail project aiming at strategic goals, shorter travel times, environmental and travel safety achievements. The Ostlänken rail line is part of the Swedish high speed rail strategy and related to the European TEN-T transport network. The whole Ostlänken rail connection consists of some part sections with several alternative corridor alignments and is presently under evaluation (KHR Rundquist & Andersson Jönsson, 2007) and (Banverket, 2008). The case concerns the appraisal of four alternative corridor alignments and a variety of both monetary and non-monetary criteria are considered.

This case study deals with the evaluation of the part section of Ostlänken from Norrköping to Bäckeby. This part section is part of a research project concerned with development of decision support systems suited for public transport projects (Vinnova, 2009) and has four alternative alignment proposals: Red, Blue-long, Blue-short, and Green, (Banverket, 2008). All the alternatives are describing a corridor and not a specific alignment. The corridors are named with colours, and short/long relates to the same corridor alternative but with two different tunnel solutions. Some characteristics of the alignments can be described as follows:

**Red**: This is the base alternative using the existing rail. It dominates the townscape in several areas and has inconsistency with the natural and cultural environment.

**Blue, long tunnel**: The alignment is to a large content similar to the Red alternative, besides from the passage of the existing townscape, as a significantly longer tunnel is used, which helps to minimise the passage problems.

**Blue, short tunnel**: The alignment is to a large content similar to the Red alternative, besides from the passage of the existing townscape, as a longer tunnel is used, which helps to minimise the passage problems.

**Green**: This alignment differs a lot from the existing line passing the existing townscape without problems. This corridor alternative proposes a soft curve around the existing townscape, but passes through areas of untouched nature, where several valleys will be split.

The four alternatives have been evaluated by a conventional CBA (Vinnova, 2009) and by a verbal MCA performed by Banverket, (Banverket, 2008). The criteria used by Banverket are also used for this case study appraisal. The MCA-criteria are: city and scenery impression, cultural environment, natural environment, recreation and outdoor life, health, natural resources, risk and safety, and building time. The defined alternatives and criteria as well as the conducted CBA and the verbal MCA will be used as input for the DST.

Application of DST to the Ostlänken case demonstrates how the DST can provide early information about how an approach to decision making based on an explicit sustainability viewpoint can influence the appraisal outcome. In the following the DST process is described and afterwards the DST results are compared to the outcome of a Decision Conference (DC) representing the 'real' process.

## 4. Application of DST to the Ostlänken case

With the alternatives and the criteria set from the start, the first step in the DST is a further understanding of the problem situation. Indications of inconsistency between the goals and the objectives of the stakeholder groups are revealed by a RP conducted as part of the initial work on the case. A number of relevant criteria are presented in the EIA carried out for this part section of Ostlänken. A sustainability strategy is defined by making a ranking of these criteria, see Table 1. The sustainability strategy depends on the defined values, see section 1, and the criteria concerning areas which cannot be completely restored if they are demolished are therefore the highest ranking.

| Criteria | Ranking |
|---|---|
| Natural environment | 1 |
| Cultural environment | 2 |
| Recreation and outdoor life | 3 |
| Natural Resources | 4 |
| City and scenery impression | 5 |
| Health | 6 |
| Risk and safety | 7 |
| Building time | 8 |

**Table 25 Overview of the criteria and how they are prioritised in relation to the sustainability strategy**

The next important step of the DST consists in scoring the alternatives under each criterion. Technically this is done by making use of pairwise comparison of the alternatives. In this case the comparison was provided by the EIA report (Banverket, 2008). Based on the pairwise comparisons, two criteria (risk and safety and building time) can be ruled out as all alternatives performed equally under these criteria. The process continues with the resisting criteria (ranking 1-6) shown in Table 1. The described steps 1 and 2 makes it possible to perform the calculations of the MCA part of COSIMA. The third step concerns a weighting together of the available CBA information with the MCA information obtained. A principal linking of the CBA and MCA is shown in Figure 29.

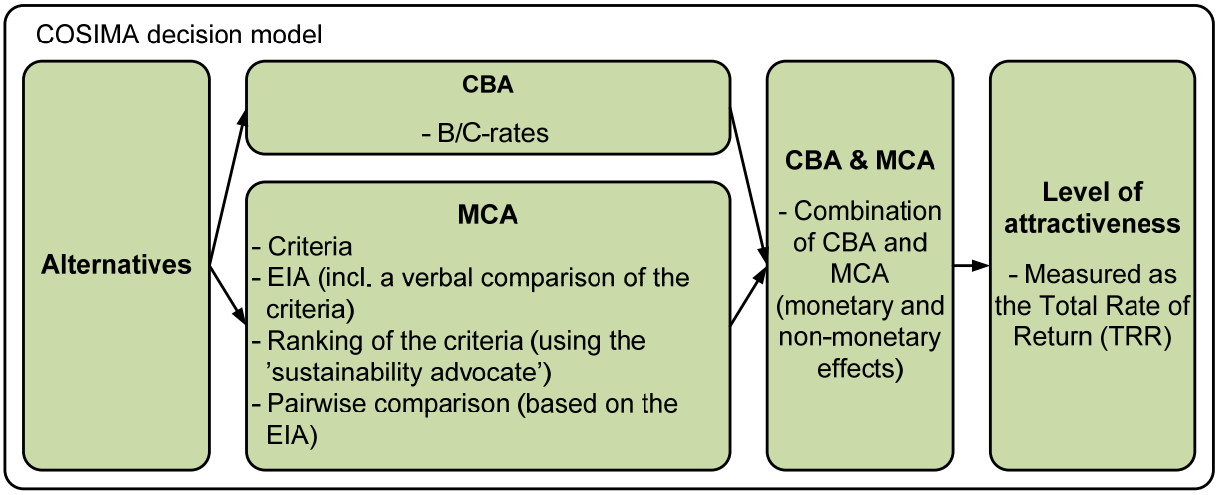


**Figure 29 Overview of the COSIMA decision model**

The DST indicates that the red corridor alternative will be the most preferable one until a MCA-% of approximately 20; at this point the red and the two blue corridor alternatives are approximately equal, and after this point, i.e. with a MCA-% above approximately 20, the blue corridor alternative with the long tunnel is the most preferable alternative. The results of the scanning performed with the DST are illustrated by the graphs in Figure 30. From this figure it can be seen that if it is chosen to access the alternatives based on a combination of the CBA and the MCA, by the TRR, the MCA-% must be above 20 to provide a change from the CBA result alone.

In the sustainability strategy the non-monetary criteria of the MCA are considered as much more important than the monetary criteria of the CBA. The DST scanning shows that if the alternatives are assessed under a sustainability viewpoint as described and if a MCA-% above 20 is chosen, the blue corridor alternatives are by far the most interesting ones. If the MCA-% for the real decision making process is chosen to be above 20, the red corridor alternative can be ruled out at an early stage and so can the green corridor alternative as it never becomes the most preferable.

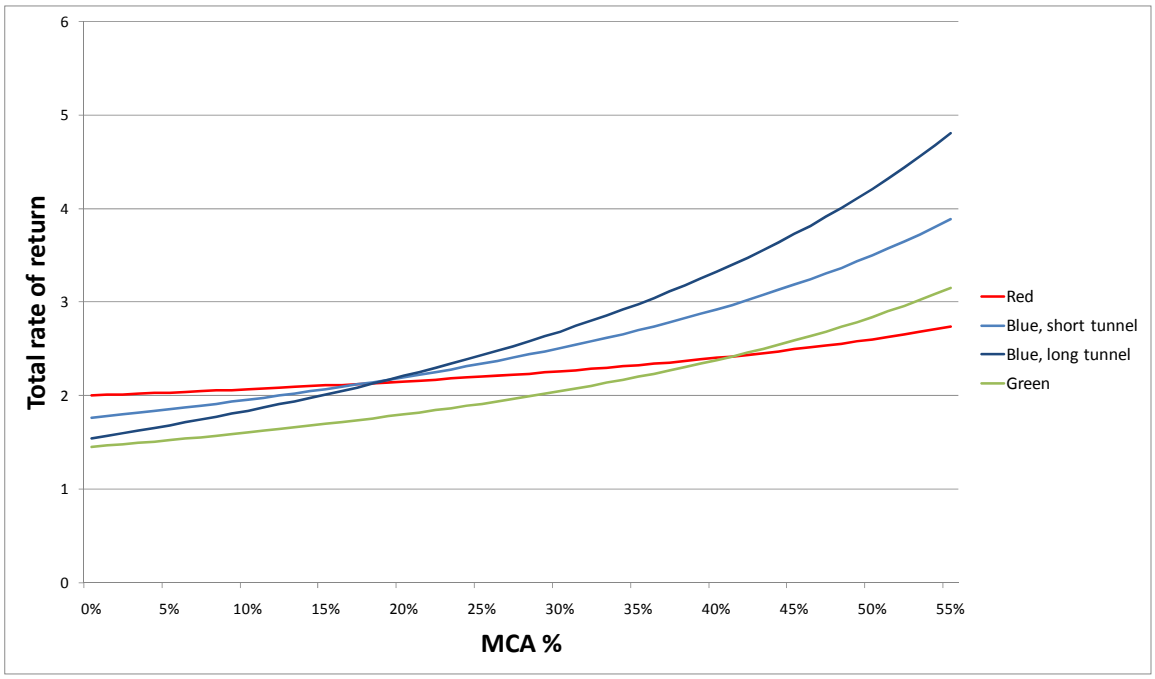


**Figure 30 DST-graphs showing the TRR equivalent to all MCA values for each of the alternatives.**

## 5. Application of a Decision Conference (DC) to the Ostlänken case

A Decision Conference (DC) based on the same decision model as applied in the DST has been conducted upon the same decision problem as in the DST. In this context it represents the 'real' decision making. The obtained DC results are used as a comparison reference to the DST results. The latter results are based on an explicit sustainability strategy, whereas the results obtained from the decision conference are based on the preferences of the participating stakeholders.

A DC is a tool which can be used to bring together stakeholders with the purpose of having a structured debate about a given problem situation. According to Phillips (2006) such conferences have helped groups to achieve a shared understanding of issues without requiring the group to achieve consensus about all issues. The most important thing for a successful decision conference is actively participating stakeholders. Other requirements are: attendance by key players, impartial facilitation, on-the-spot modelling with continuous display of the developing model, and interactive and iterative group process (Phillips, 2006, p. 5).

The decision conference was part of the Vinnova research project (Vinnova, 2009) and organised as a half day workshop, involving stakeholders who could all be characterised as experts on their field. The process was structured as a debate about the criteria defined in the EIA. In this case the predefined criteria from the EIA report were used. The conference was guided by a facilitator supported by two model technicians using the COSIMA decision model

to perform on-the-spot modelling of the obtained results. Three expert participants attended the decision conference which was held in Norrköping in Sweden at the 27th of January 2009 from 1 pm to 5 pm. The programme, the facilitator and the model technicians were presented to the participants during the introduction to the intervention. The first task was to prioritise the criteria through a group decision, where the participants were asked to achieve consensus about the importance ranking of the criteria. Eventually the structured debate summarised the prioritising as shown in Table 2. This input was applied to the COSIMA decision model.

| Criteria | DC Ranking |
|---|---|
| Cultural environment | 1 |
| Natural environment | 2 |
| City and scenery impression | 3 |
| Recreation and outdoor life | 4 |
| Natural Resources | 5 |
| Health | 6 |
| Risk and safety | 7 |
| Building time | 8 |

**Table 26 The DC participants joint prioritising of the criteria from the EIA report**

Afterwards the participants were asked to go through a complete pairwise comparison of the corridor alternatives under the criteria one by one. Information about which alternative was the better (and how much better) than the other in the comparison or if they performed evenly under the criterion was filled into the decision model. When all the pairwise comparisons were completed the participants were introduced to the CBA–results (which they had been provided on before hand) and informed about the theoretical understanding of the concept MCA-%, which they were to decide afterwards. A group discussion very soon led to a consensus about working with a MCA-% of 50. In fact this was the initial suggestion from all three participants. The results of the group process were then computed in the decision model, see the technical endnote.

If the complete set of results is scrutinised it can be seen that the red corridor alternative is the best until an MCA-% of about 10, and that the blue corridor alternative with the short tunnel will be the most attractive alternative when the MCA-% is chosen to be above 10. Figure 31 illustrates the development of the TRR for all alternatives with regard to MCA-%. This clearly illustrates how the red and the green corridor alternatives are not of interest with a MCA-% above 10. Figure 31 furthermore shows that even though the blue corridor alternative with a long tunnel never becomes the most preferable, it follows a curve with a shape approximately identical to the one of the blue corridor alternative with a short tunnel.

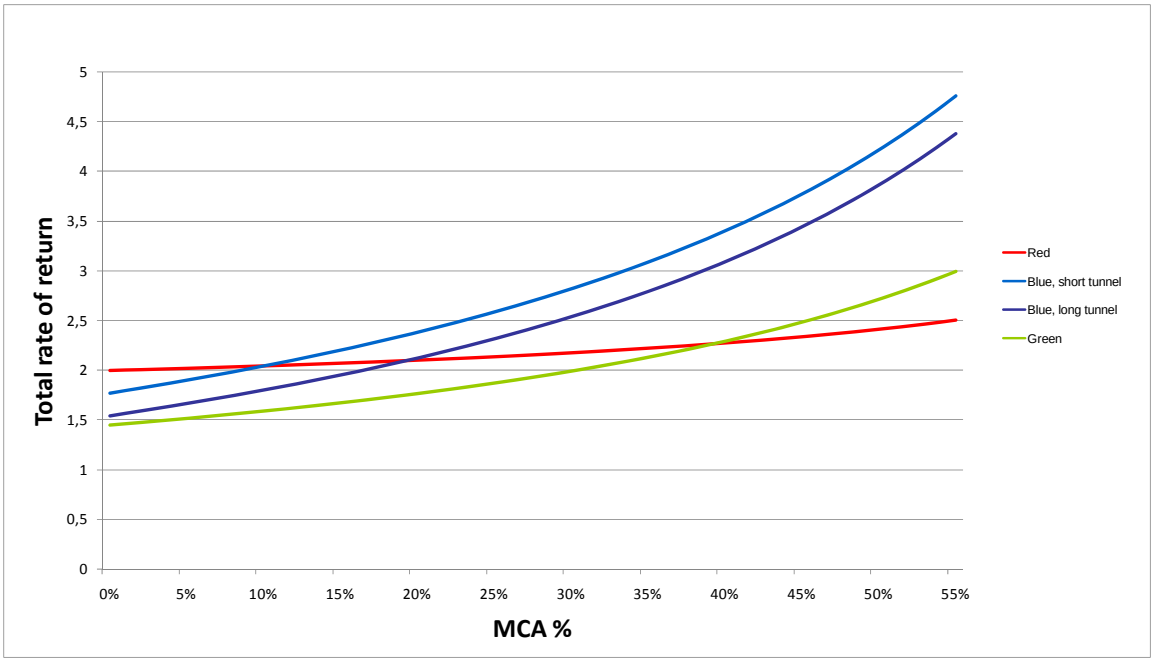


**Figure 31 DC-graphs showing the TRR for all MCA-% values for all four corridor alternatives (Vinnova, 2009)**

## 6. Comparison of the two applications of decision support

In the DST the criteria in the sustainability strategy were prioritised according to the identified key values described in section 1. Afterwards the scoring of the alternatives under each criterion showed that two criteria (risk and safety and building time) could be ruled out as all alternatives performed equally with respect to these criteria. They are therefore shown as blanks in Table 3. The same criteria set was used in the DC, where the participants, however, prioritised them differently from the sustainability strategy criteria ranking in the DST. The DST and the DC criteria rankings are shown in Table 3. Note that the criterion 'health' was the only one that obtained the same prioritising in the two approaches.

| Criteria | DST, sustainability strategy ranking | DC, participants ranking |
|---|---|---|
| Natural environment | 1 | 2 |
| Cultural environment | 2 | 1 |
| Recreation and outdoor life | 3 | 4 |
| Natural Resources | 4 | 5 |
| City and scenery impression | 5 | 3 |
| Health | 6 | 6 |
| Risk and safety | | 7 |
| Building time | | 8 |

**Table 27 Criteria ranking in respectively the DST and the DC**

The DST scanning was completed with a sustainability strategy choosing no specific MCA-%. It was only stated that the MCA was much more important than the CBA, which points towards a MCA-% higher than 50. The participants of the DC chose a MCA-% of 50.

A large similarity between the two sets of results (see the graphs in Figure 30 and Figure 31) is the information that the green corridor alternative never becomes interesting and can be ruled out at an early stage. Another similarity is that the red corridor alternative only becomes interesting with an MCA-% approximately below 20 (DST) and 10 (DC), respectively. Other information which can be drawn from the results is that the change of the most interesting corridor alternative in both approaches happens at a low MCA-%, and the corridor alternative which becomes the most interesting at this point stays the most preferable.

The DST points out the two blue corridor alternatives as being of interest for further investigation, and the DC appoints the blue alternative with the short tunnel as the experts' decision and the blue corridor alternative with the long tunnel as the second most interesting. In both cases the blue corridor alternatives are thereby the most interesting and the ones to investigate further and eventually choose between.

As described, the DST sustainability strategy and the DC 'real' results do not differ much. In this respect, it can be noted that the DST could also have been used with another strategy implementation than sustainability. If, for example, a strategy built upon values concerned with economic considerations is adapted another result will be obtained. With an economic ranking as shown in Table 4 the results in Table 5 appear. These may be interpreted in the following way: with the sustainability strategy an MCA% of 50 may be likely, whereas an MCA-% of 10 may be more likely with an economic strategy. This serves to illustrate that the DST applied on the economic strategy instead of the sustainability strategy will produce another result, with the red alternative to be preferred to the blue long.

| Criteria ranking | Sustainability strategy | Economic strategy |
|---|---|---|
| 1 | Natural environment | Natural resources |
| 2 | Cultural environment | Health |
| 3 | Recreation and outdoor life | Natural environment |
| 4 | Natural resources | Cultural environment |
| 5 | City and scenery impression | City and scenery impression |
| 6 | Health | Recreation and outdoor life |

**Table 28 Overview of the criteria ranking in the sustainability and the economic strategies applied in the DST, respectively.**

| MCA-% | Sustainability strategy | Economic strategy |
|---|---|---|
| 10% | Red | **Red** |
| 30% | Blue-long | Blue short |
| 50% | **Blue long** | Blue short/long |

**Table 29 Results of the sustainability and the economic strategies, respectively, with regard to different MCA-%. The bold result indicates the recommendation of the DST based on each strategy**

## 7. Conclusion and perspective

A scanning based on the DST is based on the use of semi-soft and hard methods and thereby not on direct stakeholder information. Application to the Ostlänken case has shown that this approach is useful as a scanning tool indicating how real stakeholders may perform and decide. When moving from the pre-decision making use of semi-soft-methods to the actual planning involving real stakeholders, a DC based on soft and hard methods can be used to ensure a structured debate based on group techniques, IT and technology.

The three modules of the DST provide an approach to operationalise the concept of sustainability by working out a sustainability strategy. The strategy is used to explicate the sustainability viewpoints. The strategy necessarily depends on the criteria and alternatives defined in module one. These are therefore of great importance for the results as they determine how the concept of sustainability is concretely defined in the process. Seeing it as an 'advocate' ensuring that sustainability issues are incorporated in the planning and decision making process therefore necessitates that each of the DST steps must be validated as concerns the information used and processed. Thus the 'advocate' is only as strong as the criteria relevant to express and evaluate the viewpoints of sustainability.

The pre-decision making assessment of the Ostlänken part section from Norrköping to Bäckeby under a sustainability viewpoint has shown that the DST is capable of providing information relevant for the 'real' planning and decision making process. The DST scanning indicated that when assessed under the sustainability strategy the two blue corridor alternatives would be of interest and that the red and green corridor alternatives could be ruled out at an early stage.

Comparison of the outcome of the two approaches to the Ostlänken case shows that the pre-planning scanning with the DST sustainability strategy and the real planning with stakeholders in the DC had several similarities. They both identified the two blue corridor alternatives as the most preferable ones, and they both indicated that the green corridor alternative never becomes of interest and that with a MCA-% above 20 the red corridor alternative can be ruled out as well. The similarity of DST sustainability strategy and DC 'real' results in the case

study may be interpreted to indicate that the participants of the DC represented the sustainability viewpoints well. In cases where this is not so, the DST will be useful as a tool that makes it possible to indicate the best sustainable alternative to be set against the alternative that may be preferred and set on the agenda by a 'strong' stakeholder.

The DST provided an enlightening pre-planning input which could have ruled out two alternatives before the actual planning process started. This indicated that the DST can serve as a scanning tool for planners and decision makers to simulate explicit sustainability viewpoints at an early stage and thereby help to simplify the planning process.

In this paper it is demonstrated how the DST can explicate the concept of sustainability for transport planning through a sustainability 'advocate' who represents the sustainability viewpoints as a sustainability strategy throughout a decision process. This enables the concept of sustainability to shift from being an implicit part of planning and decision making to being an explicit part. The impact of the sustainability viewpoints are thereby enhanced in a transparent way, which can help planners and decision makers while they are working with complex transport planning problems and decision making. The DST furthermore makes it possible to test other strategies relevant to the decision problem, e.g. an economic strategy. This can be especially relevant if the CSH reveals a stakeholder group with great influence on the decision or a stakeholder group which is in complete opposition to the applied strategy, e.g. a stakeholder group in strong opposition to the sustainability viewpoint. The possibilities and use of the DST in planning situations can be developed and refined in such a way that more viewpoints than the ones of the explicit sustainability advocate can be present in the planning process.

**Acknowledgements**

The Vinnova project provided an excellent chance to test the developed semi-soft Decision Simulation Technique (DST) and compare the pre-decision making scanning results with data obtained from a decision conference. The Vinnova project has thereby been of virtual importance for testing DST. Furthermore, my colleagues in the Decision Modelling Group at DTU Transport have been most helpful regarding the use of the decision model and our joint performance of the decision conference in Norrköping on the 27th of January 2009.

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## Technical Note: The COSIMA decision model

The COSIMA decision model allows decision makers to conduct a composite analysis of a given decision problem. The main methods are the conventional cost-benefit analysis (CBA) which deals with the monetary impacts and the multi-criteria analysis (MCA) which is used to determine the effect of the non-monetary impacts. The decision model permits a combination of input from a CBA and a MCA into a Total Rate of Return (TRR). The TRR is calculated by the equation below, see (Salling et al., 2007). The equation describes how the sum of the non-

monetary benefits is multiplied with a calibration factor α and added to the sum of the monetary benefits for a given alternative. These are then divided by the sum of the costs regarding the alternative.

$$TRR(A_k) = \frac{1}{C_k} \cdot \left( \sum_{i=1}^{I} V_{CBA}(X_{ik}) + \alpha \cdot \left[ \sum_{j=1}^{J} w(j) \cdot V_{MCA}(X_{jk}) \right] \right)$$

| | |
|---|---|
| $\alpha$ | The calibration factor that expresses the model set-up's trade off between the CBA and the MCA |
| $A_k$ | Alternative k |
| $C_k$ | The total costs of alternative k |
| $TRR(A_k)$ | Total rate of return for alternative k |
| $V_{CBA}(X_{ik})$ | The value in monetary units for the CBA effect *i* for alternative *k* for altogether *I* CBA impacts |
| $V_{MCA}(X_{jk})$ | The value-function score for MCA criterion *j* for alternative *k* for altogether *J* MCA criteria |
| $w(j)$ | The weight that expresses the importance of criterion *j* |
| $X_{ik}$ | CBA effect *i* with regard to alternative *k* |
| $X_{jk}$ | Criterion *j* with regard to alternative *k* |

The CBA elements, e.g. the monetary cost, $C_k$, and the benefits, $\sum_{i=1}^{I} V_{CBA}(X_{ik})$, are calculated as in a conventional CBA and will not be further described here, see among others (Salling et al., 2007) for a full detail description. This is referred to as the CBA part of the COSIMA analysis. The MCA part, $\alpha \cdot \left[ \sum_{j=1}^{J} w(j) \cdot V_{MCA}(X_{jk}) \right]$, is based on applying additive value functions, used to assess the alternatives with regard to the criteria. There are several techniques which can be applied to conduct the MCA. The techniques used in the decision model for the present case is briefly outlined step by step in the following paragraphs.

First step is to prioritise the criteria according to their importance. The prioritising is based on the SMARTER method, see (Goodwin & Wright, 1998) applied with Rank Order Distribution (ROD) weights, see (Roberts & Goodwin, 2002). These techniques only require the decision makers to rank the MCA criteria in order of importance, without a specification of the weightings, as these are determined directly by the ROD technique. The step determines the importance weight of each criterion, the w(j).

Following is 'direct rating using pairwise comparisons' used to assess all alternatives towards each other under all criteria, see (Belton & Stewart, 2002). The pairwise comparisons are

based on the REMBRANDT technique, see (Olson et al., 1995). The comparisons are used to produce value-function (VF) scores. These scores are then multiplied by the ROD weights.

Finally, the MCA part is multiplied by a calibration factor, α, which indicates the trade-off level between the CBA and MCA. This trade-off basically describes the level of importance subscribed to the MCA when it is added to the CBA. The decision model is used to transform the monetary CBA impacts and the non-monetary MCA impacts into the same 'language'. This is done by assigning fictitious monetary values to the non-monetary elements, using the calibration factor α and the weight indicating the importance of criterion j, w(j). This language is not to be compared with the conventional economic language, and the TRR is to be seen simply as an indicator of the individual attractiveness of the compared alternatives.

The CBA results are at all times kept 'intact', as the TRR are merely increased in the calculation by the chosen level of the MCA, expressed by a relative percentage, indicated by the MCA-%. The level of the MCA-% can vary, dependent on the decision makers' approach to the decision problem and how they rate the importance of the MCA. If the CBA and the MCA are equally important the MCA-% will be 50. If only the CBA is counted and the MCA is considered not to be of importance at all the MCA-% will be 0. If the MCA is much more important than the CBA, the level of the MCA-% can approach 100.

The TRR determined for each of the alternatives can be used as an indicator of the alternatives' individual attractiveness and illustrated as a function of the MCA-%. This function can be used to illustrate where the MCA part provides a change with regard to which alternative is the most attractive. If the decision model is applied with a number of stakeholders it can be used to illustrate their different preferences and their approach to decision making.

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## 4.8 Overview of paper 4

### *Use of short decision conferences (DC) in Systemic Intervention*

| | |
|---|---|
| Title: | Use of short decision conferences (DC) in Systemic Intervention |
| Author(s): | Jeppesen, S. L. |
| Presented: | UKSS 2009 conference, Oxford, England, 1st-2nd September 2009 |
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**Paper description**

This paper seeks to introduce participative methods to complex transport planning and decision making. Futures Workshop (FW), Vision Conferences (VC) and Decision Conferences (DC) have all been scrutinised in order to define their individual strength and applicability in the transport planning process. Decision Conferences were found to be relevant as they in a flexible way bring decision analysis and group processes together leading to a structured debate among participants.

The proposed decision conferences vary from those found in the literature as they use the COSIMA decision model and a pre-planned framework and therefore require the input to produce the output outlined in Figure 32. The proposed DCs are based on reflection upon three parameters, which are important to implementation of DCs in transport planning: number of participants, types of participants, time available. The DCs have different purposes: some are very short conferences involving only experts/professionals and some are involving all types of stakeholders. The DCs have different durations depending on the purpose of the conferences and where in the process they are applied. Four generic DC types are proposed, see Figure 33: 'Short A' accommodates 2-4 experts/professionals in a timeframe of ½-1 day. 'Short B' accommodates 5-10 experts/professionals in a timeframe of ½-1 day. 'Standard C' accommodates 5-10 of all stakeholders in a timeframe of 1½-2½ days. 'Standard D' accommodates 11+ of all stakeholders in a timeframe of 1½-2½ days. 'Standard C' and 'standard D' are based on the literature and 'Short A' and 'Short B' have been formulated within this study to fill a need for shorter expert oriented versions. 'Short A' and 'Short B' is in paper 4 shortened as short DCs (DCs) an in the main text of this PhD thesis as Short Decision Conferences (SDCs).

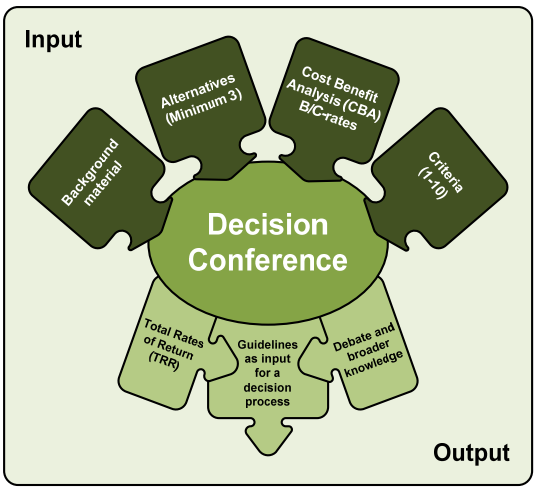


**Figure 32 Input and output of a decision conference adapted from (Jeppesen, 2009b)**

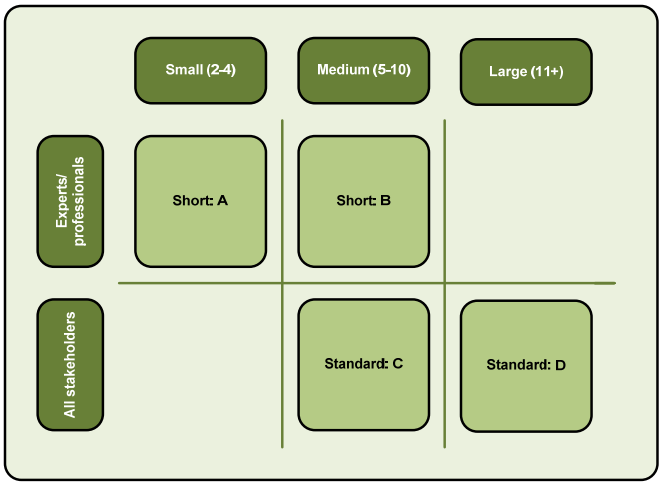


**Figure 33 Proposed generic Decision Conference types adapted from (Jeppesen, 2009b)**

Two case applications were made in the area of public transport planning. One case represented a 'Short A' with 3 participants with a duration of half a day and the other case represented a 'Short B' with 10 participants also with a duration of half a day.

### Main findings

Decision conferences are well suited when dealing with complex transport planning problems and can be implemented in transport planning and used to improve the decision making process by enabling involved and affected stakeholder groups to state their opinion. Based on the literature, two standard decision conferences were identified and these were supplemented in a tentative way with two shorter decision conference types, in order to make decision conferences more applicable in complex transport planning. The short decision conferences were tested in practice and found to be worthwhile when dealing with projects either at an early stage or when verifying e.g. material from an EIA. Standard DCs are still considered to be very applicable at the end of the planning process. It was found that DCs can play a major role helping to explicate the three dimensions of the concept of sustainability within transport planning. The social dimension can be explicated by the participating stakeholders, the economic dimension can be explicated by the use of B/C-rates and the environmental dimension can be explicated by the use of soft criteria in the process.

The case applications to 'real-life' problems provide information about how the short decision conference functions in a real planning process. The participating professionals were in general very positive and stated that they would like to participate in similar events. The formulation of the short decision conferences and their practical testing is considered as one of the major findings of this PhD study.

## 4.9 Paper 4 Short Decision Conferences (SDC)

**Use of short decision conferences (DC) in systemic intervention**

*Presented at UKSS 2009*
*Accepted for publication in the Systemist. Expected to be in the Systemist, Vol. 32 (1) 2010, the United Kingdom Systems Society*

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**Abstract**

This paper introduces the use of short decision conferences (DC) in systemic intervention with a specific focus on the problem-solving design for complex transport problems. DCs can help deal with complex problem situations and explicate the concept of sustainability in the transport planning process. Four types of DCs are presented, based on three overall parameters: number of participants, types of participants and the available time. Two DC applications are presented, resembling two of the four DC types outlined. They provide lessons learned as well as perspectives and recommendations on how to plan and use DCs in a transport planning context.

**Key words:** Short decision conference, systemic intervention, stakeholder involvement, sustainable transport planning

### 1. Introduction

Decision making processes within transport planning are often complex and involve and affect many stakeholders. When large transport planning needs or visions occur, the process from generating alternatives over the assessment to the decision making and implementation can be extensive and complicated, and make it difficult for affected stakeholders to make their voices heard. Studies have indicated that systems thinking and soft OR methods can be helpful when working with complex problem situations, se among others (Checkland, 1993/1999), (Midgley, 2000), (Jackson, 2003), (Vidal, 2006b), and (Leleur, 2008).

Recent studies have shown that wider economic benefits can have a great influence on the assessment of the attractiveness of a set of alternatives (Crossrail, 2009). This study showed that both monetary and non-monetary criteria were of importance when assessing public

transport investments. It is difficult to assign a value to the wider economic effects or non-monetary effects, and they are often assessed differently by stakeholder groups. It can therefore be very relevant to design decision support systems which take account of both monetary and non-monetary criteria and stakeholders with different worldviews. Several types of participative methods can be used as framework for conducting such workshops, each of these holding different sets of pros and cons, depending on aim, time and resources. This paper focuses on the use of Decision Conferences (DC) in transport planning, but will draw on other methods as well. DCs allow for a selection of stakeholders to have a structured debate regarding the decision problem (Phillips, 2006) and enable an opertionalisation of the concept of sustainability with regard to the transport planning process (Jeppesen, 2009a).

The first section introduces the paper and the need for participative methods in transport planning. The second section briefly introduces some of the complexity often dealt with within transport decision problems. Section two furthermore outlines the three considered participative approaches to decision making, how they can be used in relation to transport planning and why DCs are chosen as the most suiting option for the transport planning problems in question. A brief outline of the decision model which is used for on-the-spot modelling in the DC is also given. The third and fourth sections describe the case studies and lessons learned from these. The fifth section provides a few recommendations regarding choice of DC type, and finally the conclusions and perspectives are presented in section six.

## 2. Transport planning and participative approaches to decision making

Several factors have influenced the increasing complexity level within transport planning and decision making, especially regarding large transport investments. Some of these are the rising number of cars, constraints from development of the built environment, the impacts on road users, environment and surroundings, the number of stakeholders who are taken into consideration, and the growing awareness of the long term perspective, see among others (Jeppesen & Pedersen, 2005) and (ATV, 2005, 2008). The concept of sustainability is often part of the transport planning process too and can also affect the complexity level of the decision problem, as it influences both short and long term planning and regards social, economic, and environmental issues (Jeppesen, 2009b).

Development of computer capabilities has furthermore enabled the use of advanced appraisal methodologies with increasing sophistication. Decision support based on sophisticated software holds possibilities for evaluation of large amounts of data, using a number of different methodologies, which can be mixed and matched into a Customised Decision Modelling system (CDM), see among others (Leleur et al., 2007). The complexity of a decision problem can have many dimensions. Deciding which methodologies to use and

gathering of data is one dimension, the number and influence level of stakeholders another, and the long term perspective and the objectives for decision making is a third one. All dimensions are important factors in the transport planning and decision making process.

Planning of large infrastructure elements and investments undergoes different appraisal types dependent of the project size. In cases with a large impact and cost is the conventional cost benefit analysis (CBA), among others, supported by a multi criteria analysis (MCA). In traditional transport planning the conventional CBA is in most cases used to determine the feasibility of an alternative or to assess the feasibility of several alternatives. The final decision will often be based on the monetary CBA input (e.g. construction cost, maintenance, travel time savings, traffic safety, noise, emissions, etc.). The non-monetary input, also known as soft-input, regarding effects that cannot be directly assessed in monetary values, will not be considered by the CBA based on the Danish National Manual (NM) (Trafikministeriet, 2003), but can be assessed using a MCA. The MCA enables effects defined e.g. by a Strategic Environmental Assessment (SEA) or an Environmental Impact Assessment (EIA), public hearings and stakeholder interaction to be part of a joint assessment together with the CBA. Decision making processes can be extensive and demanding. The amount of work required is correlated with the complexity level of the problem and the number of alternative solutions in question.

The complexity within transport decision problems can be addressed in different ways. Leleur (2008) argues that a systemic approach can provide tools and understanding to deal with complex problems and argues for the benefits of communicative planning and multiple stakeholder views. Stakeholder viewpoints can be integrated through systemic multi-methodological approaches to decision making, stakeholder participation, and use of soft OR methods.

### 2.1 Participative approaches to decision making

Within the soft operational research methods there are several approaches to participative decision making. The methodologies are most commonly formed as workshops lasting from half a day to several days. When dealing with complex transport planning problems, there are at least three participative approaches to decision making which can be very useful, i.e. the Future Workshop (FW), the Vision Conference (VC) and the Decision Conference (DC).

The FW was developed to support community groups and their interests and viewpoints in political struggles regarding their local community and their future and can be used to support creativity and create synergy within a group of 15-20 persons. FW consists of five phases: the preparation phase, the critique phase, the fantasy phase, the implementation phase and the

follow-up phase and can accommodate a large number of participants, see (Vidal, 2006a) and (Vidal, 2006b). The key elements of FW are the collective decision-making processes and the use of creative methods. The FW can be helpful early in the transport planning process, when a problem is detected but not defined. It could be used before the actual planning is started to gather information about the wishes, needs and desires of the affected stakeholders. It could emphasise what the problem(s) are through the critique phase and generate ideas and solution proposals (e.g. alternatives) through the fantasy phase. It enables a creative process with room for many participants which could inform planners and decision makers about which themes to address and provide ideas of where to search for solutions. The two presented cases have passed this phase as several alternatives have been proposed in each case and a set of evaluation criteria has been designed.

The VC was designed for groups to develop a common vision for the future regarding a specific theme. A VC is suitable for involving large and diverse groups affected by larger systems which include many actors. The VC was developed as a one-day workshop for 30-60 participants, which would be divided in sub-groups of 7-12 participants each with a facilitator. The workshop develops around themes which the participants fell related to/want to respond to and consists of a divergent phase including an invited speaker to start with and followed by a convergent phase. The key elements of a vision conference are to learn about ideas from different actors, different actors get to communicate their visions to each other, learning to design and manage vision conferences, see (Vidal, 2003) and (Vidal, 2006b). The VC can be used in the transport planning process as a mean for working with a set of defined themes or problem situations. These could be predefined by the planning authority or they could be defined using ideas from e.g. the critique phase of a FW or regarding a specific set of alternative proposals. A VC accommodates the possibility to involve a large quantity of participating stakeholders. The design of a VC as a one-day workshop could be beneficial for a transport planning process, where time is always a limited resource. If the VC is used before the decision making process begins, it can be used to give a verbal appraisal by affected stakeholders to the planners before the planning process has come ‘too far’. The presented cases are past this point, as an overall goal is outlined in both cases and the decision making is in process.

A DC consists of three key elements: decision analysis, group processes and information technology, (Goodwin & Wright, 2004, p. 323) which can be used to bring stakeholders together for a structured debate about a given problem situation and it can help groups to achieve a shared understanding of issues, without requiring the group to find consensus about all issues but reaching ‘accommodation’ (Phillips, 2009). The most important issue for a successful DC is actively participating stakeholders, attendance of key players, impartial

facilitation, on-the-spot modelling with continuous display of the developing model, interactive and iterative group process (Phillips, 2006, p. 5). The conference can have numerous layouts, as it is designed to suit the decision problem in focus and the mix and number of participants. The participants can be either all stakeholders or a few selected ones. A key issue for a DC is that there are no fixed agenda and no prepared presentations. The DC develops based on a planning phase prior to the DC and the input generated during the DC and is guided by an impartial facilitator (Phillips, 2009). The process will often be based on a multi-methodology approach consisting of both hard and soft methods. A DC will often include introduction meetings where aim and requirements can be defined. Furthermore the decision problem, the participants, or the decision makers will be specified and the existing information regarding the decision problem can be brought forward to all participants. Phillips & Bana e Costa (2005) outlines a process of a DC, consisting of the formation of a strategy team, a kick-off meeting, team meetings, reviews by senior managers, a merge meeting and finally an evaluation and digesting period followed by recommendations. This whole process will be spread over a longer period and involve stakeholders on different levels in the organisation. This setup can be used as a frame for the whole process, but must be seen as a framework which can be fitted to the given problem situation. The approach presented to accomplishment of a DC furthermore presents a combination of multi-criteria decision analysis (MCDA) and decision conferencing in relation to resource allocation and portfolio planning. This work, based on a socio-technical approach to decision making, pinpoints that more time should be used on the social process than on advancement of the model (Phillips & Bana e Costa, 2005).

DCs can help to guide participants towards a decision and will often be situated at the end of the planning process, but can be used earlier in the process, depending on the aim. For further input early in the transport planning process the Decision Simulation Technique (DST) can be of assistance providing planners and decision makers with a preview of which alternatives that would be the most attractive under a given strategy, e.g. a sustainability strategy (Jeppesen, 2009a). For early input and assessments methodologies such as the formerly introduced FW and VC can also be beneficial in a transport planning context. A few benefits which can be obtained using FW, VC, and DC are outlined in Table 30.

The scope here is to establish a short participative method and although FW, VC, and DC all contain important elements to facilitate creative inputs, it was decided to focus upon the possibilities contained in the DC due to the use of structured debate in combination with IT-based on-the-spot modelling.

| Futures Workshop (FW) | Vision Conference (VC) | Decision Conference (DC) |
|---|---|---|
| • Collective decision making<br>• Critique of the existing situation<br>• Empowerment of stakeholders<br>• Group creativity, idea, and synergy creating<br>• Team work and democracy (all participants are equal)<br>• Well suited for 'community' related issues | • Accommodates very large groups<br>• Creative methods<br>• Common vision and strategies<br>• Communication of visions from different stakeholders<br>• Group dynamics and collective work<br>• Learn about different actors' ideas and the VC process | • Encourage group processes and knowledge sharing<br>• Guidelines for decision making<br>• Multiple stakeholder views<br>• Participative use of a decision model and decision analysis<br>• Structured debate<br>• Use of IT and technology during the conference |

**Table 30 Benefits obtainable using FW, VC, and DC**

In the proposed DC outline, the decision model is used to structure the inputs from the debate and to compute the results used for the final discussion and the resulting decision making guidelines. During the DC, the decision model is handled by a model technician and not until the end of the session is the output presented for the participants in the DC. This is not in compliance with (Phillips, 2006), but has proven a good solution as the changing numbers and graphs in the decision model can remove focus from the debates. The applied decision model is used to support and operationalise two of the key values in a DC, namely, decision analysis and information technology and serves as an IT aid to conduct on the-spot-modelling and provide instant results of the participants' debate.

The decision model is developed upon an MS Excel platform and can be run from an ordinary PC. It requires a series of inputs for the CBA for each of the proposed alternatives, either a pre-calculated B/C-rate or inputs for calculating this. Furthermore a set of criteria is needed for the MCA. The input from the participants is then treated with a series of theoretical well-founded methods to prioritise the criteria, conduct pairwise comparisons of all alternatives towards all criteria, develop value functions, and finally compute all the information in to an attractiveness measure, Total Rate of Return (TRR), see (Salling et al., 2007) and (Jeppesen, 2009a) for further information on the decision model and the underlying theories. Due to the design of the decision model a minimum of 3 alternatives is needed and 1-10 criteria can be included. The input needed and the output provided from a DC based on this decision model is outlined in Figure 34.

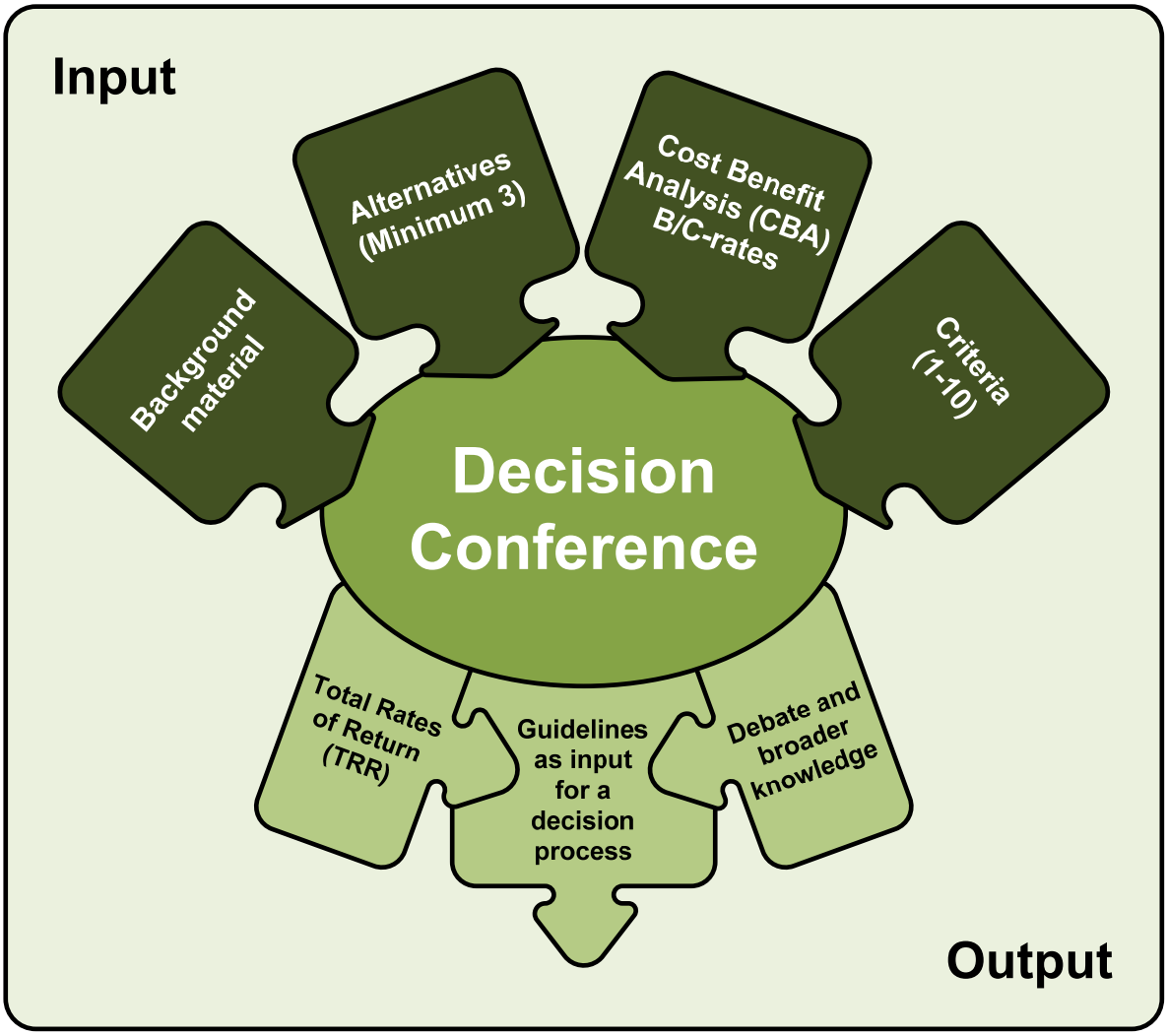


**Figure 34 Input needed for and output provided by the outlined DC**

The decision model is based on a multi-methodology approach consisting of hard methods and can be used to combine results of a CBA with the results of a MCA resulting in a measure of the alternatives' attractiveness expressed by a TRR. The TRR is used as an indicator as to which of the alternatives is the most preferable, for further information, see (Salling et al., 2007). The result of the analysis is based on using CBA, NM, MCA and DC, see Figure 35. In this context, it should be noted that the DC based on inputs (determination of criteria set and scoring by pairwise comparisons of criteria and priority-ranking of criteria) makes it possible to establish an open-valued and transparent evaluation process where the participants become fully integrated into the evaluation.

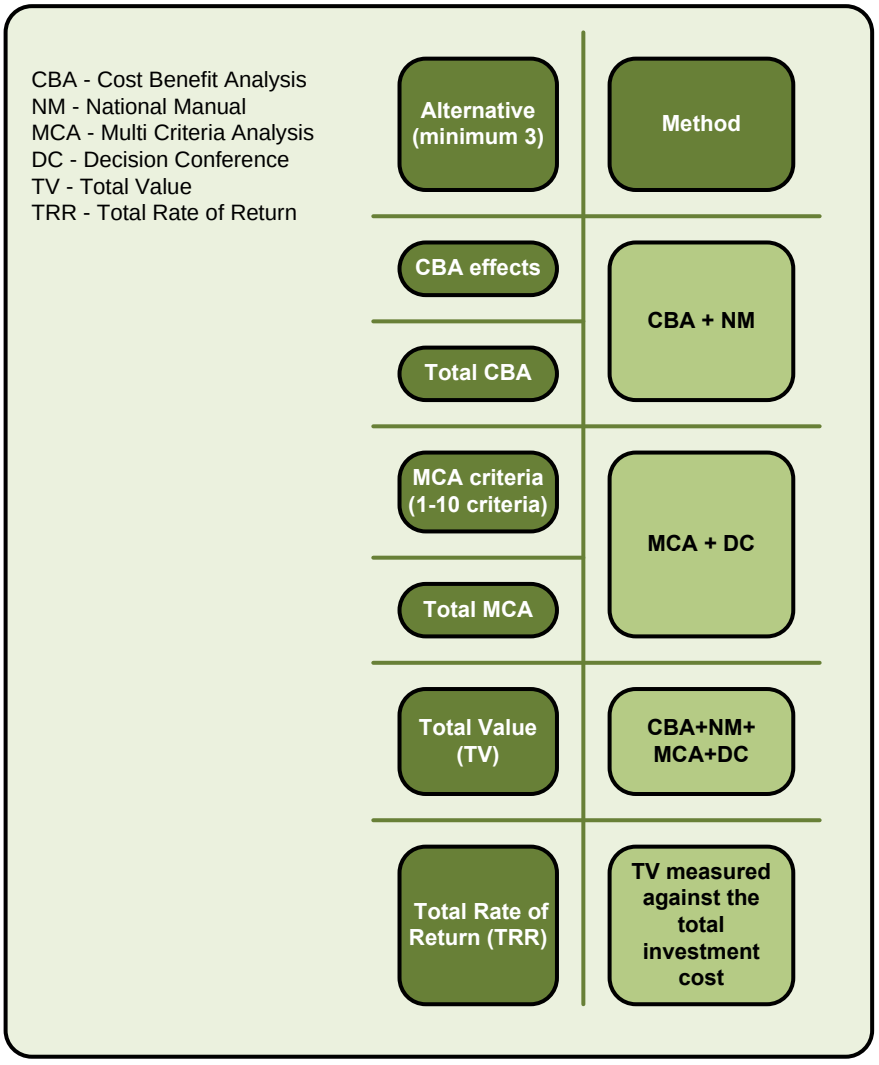


**Figure 35 Outline of the calculations conducted by the decision model**

## 2.2 Four types of DCs applicable in transport planning

The use of DCs in transport planning matters will often not be relevant until the problem situation is defined, a number of alternatives is defined and possibly with a number of criteria outlined, defined or quantified. The presented DC types will be using fixed agendas and presentations and they will therefore not be following the recommendations of Phillips (2009) not to do so, neither will the presented DC types follow the outline of (Phillips & Bana e Costa, 2005). The proposed DC layout shall be seen as the result of a preparation phase and can be regarded at the same level as the merge meeting in Phillips & Bana e Costas outline. The proposed DC will follow a pre-planned time schedule and be based on an underlying presentation, which will guide the intervention through a series of steps related to the content of the underlying decision model. The proposed outline of four DC types will all be partly defined by the 'standards' provided in the literature (Goodwin &Wright, 2004), (Phillips & Bana e Costa, 2005), (Phillips, 2006), and (Phillips, 2009) and partly developed upon the

concept of DCs with inspiration from both FW and VC. The influence from FW and VC will, besides from adopting of the planning phase and the overall plan for the content of the intervention, also bee visual in the adjustment of the DC to the number of participants and available time. Furthermore the proposed DC types will adopt some of the creative elements from FW and VC, receptively, if there is a need for definition of alternatives and criteria.

The DC outlines are based on three main parameters, number of participants, types of participants and the available time. These parameters can be combined in several ways. Four types of DCs are outlined in Figure 36 and named 'Short: A', 'Short: B', 'Standard: C', and 'Standard: D'.

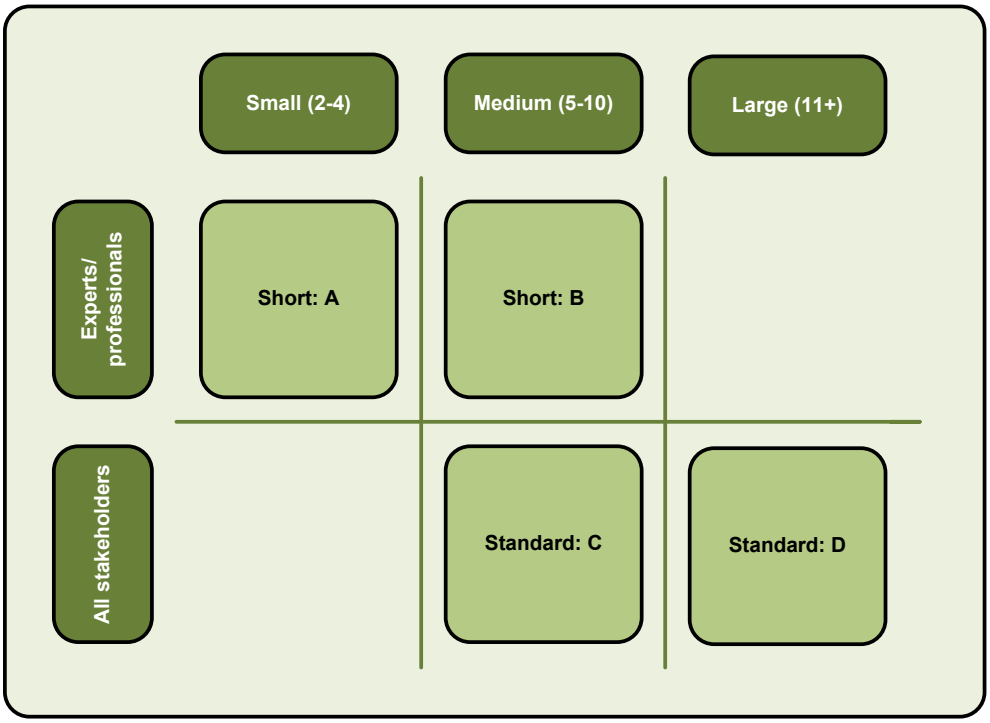


**Figure 36 The four DC types outlined for transport planning and named 'Short: A', 'Short: B', 'Standard: C' and 'Standard: D'.**

The two proposed participant groupings describe two different setups, one only considering experts/professionals directly involved in the process and the other describing a public process where both involved and affected (all) stakeholders are represented. The number of participants is referred to as small (2-4 participants), medium (5-10 participants) or large (11+ participants). The participants are categorised as either experts/professionals or all stakeholders.

'Short: A' and 'Short: B' describe a DC layout under a time constraint of ½ day to 1 day and is therefore denoted 'short'. 'Standard: C' and 'Standard: D' describes a DC layout without a

time constraint and duration of 1½ -2½ days and is therefore denoted ‘standard’ due to its reference to the DC proposed in the literature see, (Goodwin & Wright, 2004), (Phillips & Bana e Costa, 2005), (Phillips, 2006), and (Phillips, 2009).

DC type ‘Short: A’ accommodates 2-4 experts/professionals on a short term, half a day to one day. DC type ‘Short: B’ accommodates 5-10 experts/professionals on a short term of half a day to one day, too. DC type ‘Standard: C’ accommodates 5-10 members of all stakeholders for a longer period of 1½ to 2½ days and DC type ‘Standard: D’ accommodates 11+ of all stakeholders for a longer period of 1½-2½ days. This DC type can, depended on the number of participants, necessitate the participants, as in a large VC, to be divided into groups, each with a facilitator and a model technician. The groups may be subject to change during the intervention and there will be some plenum sessions to summarise the results of the whole group.

The four outlined DC types shall be considered as generic types which ought to be customised to each decision problem. Each DC will thereby be different and the content and outline depending on the problem situation and the existing material. How long and extensive the pre-planning phase must be depends on the purpose of the DC, the existing material, the number of participants and the time available on the day. In general the proposed DC types will go through seven general steps. Each step is subject to customisation in order to fit the decision problem in question, see (Jeppesen, 2009b).

The DC can be of relevance for the transport planning process when it reaches its final stages. It enables decision makers to obtain input regarding different stakeholder opinions and worldviews. Depending on which type of DC applied, the information can be obtained from large or small groups consisting of either experts or all stakeholders. The DC can be of use at the end of the transport planning process. The DC is relevant to the two cases as they already have obtained alternatives and evaluation criteria and are working towards the final decision of which alternative to choose.

## 3. Case 1 – a national rail planning project in Sweden

The described DC was developed and applied to a case study regarding planning of a part section of the high-speed rail road along Ostlänken in Sweden. Four corridor alternatives are proposed by Banverket. A CBA is conducted for each of the corridor alternatives. A set of evaluation criteria is defined in the Environmental Impact Assessment (EIA) which was conducted for the part section. The EIA does not propose any decision but make a verbal comparison of the alternatives towards the criteria; this information can be used in a MCA (Banverket, 2008).

The DC was planned and conducted as part of a research project under the Swedish research council, Vinnova, dealing with new approaches to assess public transport; more information about the project can be found in (Vinnova, 2009). The invited stakeholders were all considered experts/professionals. In this case the DC was designed to suit few stakeholders with expert knowledge within their field. The stakeholders were all busy people who had only limited time, but a great interest in participation.

### 3.1 DC layout – type 'Short: A'

The DC was initially designed to last a whole day. The programme was designed and a series of relevant stakeholders were invited to participate in the DC. Replies were positive, but the responding stakeholders could not find more than half a day to participate. The DC programme was therefore redesigned to a half-day workshop (four hours). The re-invited and later participating stakeholders were experts representing different fields involved in and affected by the decision problem. A total of five stakeholders accepted the invitation. There had been more positive feedback, but some participants were still hindered by other meetings and obligations. Five participants were less than hoped for, but it was decided to go through with the DC, even with this lower number, as the participants were to be considered as experts and fewer participants would provide more time for discussions in the tight half-day programme.

The half-day DC was in general structured as a debate about the criteria defined in the EIA. In this case the predefined criteria from the EIA report were used directly as a starting point for the debate. These criteria could be debated, but this part was left out when the DC was reduced from a one-day event to a half-day event. Likewise the four proposed corridor alternatives were not subject to discussion, but used directly as input for the process. The change from a one-day to a half-day workshop meant that the DC went from an open debate based on creative processes to a more structured process used to evaluate and verify the findings of the EIA, based on the participating stakeholders' knowledge. The conference was guided by a facilitator supported by two model-technicians using a decision model to perform on-the-spot modelling of the obtained results. The participants were asked to prepare themselves for the conference by studying the accessible information regarding criteria, corridor alternatives and cost-benefit analyses for these. They were also provided with a brief outline of the DC concept describing the process and what was expected of them.

The DC was held in a conference room at the city hall in Norrköping at the 27$^{th}$ of January 2009 from 1 pm to 5 pm. This location was chosen, as it would be convenient for the participants, all living in the nearby area, and as the location was part of the part section of Ostlänken which was under consideration. It was planned to use two projectors for the DC,

one to show the supporting power point show and one to show the on-the-spot modelling. It was furthermore planned to use a series of posters illustrating the corridor alternatives, criteria and the scale used for the pairwise comparisons. As described the DC programme and content were developed around the EIA.

### 3.2 Case 1 - process evaluation

The DC applied in case 1 was as mentioned first planned as a one-day event, but due to the participants time constraint the conference was turned into a half-day event. Several experts/professionals were invited to the DC and it was therefore first planned as a DC type 'Short: B' but turned into a 'Short: A' as five participants accepted the invitation and three showed up. A change from a one-day to a half-day DC reduced the time for discussions, and furthermore influenced the programme. Having only half a day for the entire DC, the set up had to be very organised from start to end which reduced the possibilities for implementation of ideas from the participants and improvisation regarding tools and methods from the facilitator due the direction of the discussions. Having only three participants, some time was gained for discussion as there were fewer opinions to be stated; each participant thereby had more time to speak. One concrete example of the time constraint and limitations on discussion regarded the choice of criteria. For the Ostlänken case it was chosen to work with the criteria determined in the EIA report. The participants had full understanding of the time constraint that they themselves had placed upon the process, but after attendance they would like to spend more time on future DCs in order to have the possibility to work with the criteria building as well. The time constraint and the set up of the DC made it clear that the total of 48 pairwise comparisons were an absolute maximum. The participants managed to stay engaged in all the discussions, but they were getting tired as the process of comparison could be regarded as monotonous, and they tended to have shorter discussions towards the end of the process as they faster adopted other participants opinions, and thereby gave up on their personal believes.

The DC was planned to run with two projectors and large posters on the walls. Due to lack of hardware the number of projectors was reduced to one. This resulted in the actual showing of the on-the-spot modelling was saved for later in the process. This caused a bit of concern before the intervention was started, but proved to be very effective. The participants paid full attention to the discussions, knowing the output was registered and typed in as they were speaking, but there were no models distracting their concentration, by being more interesting than the discussions they were having.

As there were only announced five participants for the conference it was decided to reduce the size of the material and on arrival it seemed to be a better idea to place the posters and maps

on the table, so they would be easy to include and use as reference during the discussions. This proved to be a good idea, as the participants made diligently use of it, and it was concluded that for following occasions even with more participants, it would be more useful to have the material on the table, in several copies, than to have it hanging on the wall from where it requires the participants to get out of the chair to use it actively. Getting out of the chair and the dynamics this would provide as well as reformation of the group could be of importance for some interventions.

If there had been more participants presented for the half-day workshop, this would have affected the amount of time each had to talk and the facilitation style. Each participant would have had to be very specific in their statements and the facilitation would have had to be more firm, when accommodation was sought. If there had been more participants, more time would have been needed.

With regard to the four outlined DC types 'Short: A', 'Short: B', 'Standard: C', and 'Standard: D', case 1 underpinned that 'Short: A', the shortest version with few experts/professionals as participants can serve to process or discuss official documents as an EIA and if a more free and creative process is sought or more participants are invited, then the longer versions are to be considered. The time consumption is also dependent on the participants' knowledge and the complexity of the problem situation in question.

## 4. Case 2 - appraisal of three new public transport lines in a Swedish town

This case considers the choice between three alternative lines of a new public transport system in a Swedish town. The project is the first phase of a large planning scheme considering several other lines. The lines in focus are of different length and passes through very different neighbourhoods. A thorough study has been conducted for each line and a large amount of information material has been provided as well as a conventional CBA considering monetary criteria. The municipality undertaking the planning is furthermore working with a number of non-monetary criteria, which have not been definitively decided for, although they are planning to use them as a supplement to the CBA. Though the municipality has been working with both monetary and non-monetary criteria they still believe that more information will be useful for the final recommendation to the decision makers, especially regarding how to assess the two sets of criteria against the alternatives. Application of a DC could help the planners concretise the non-monetary criteria, in terms of considering which to bring in and which to leave out to avoid 'double counting'. A DC could furthermore provide a structured debate among the involved stakeholders and provide them with a tool to conduct a composite analysis of the two sets of criteria (monetary and non-monetary).

The DC was planned and conducted as part of a research project under the Swedish research council Vinnova, dealing with new ways to assess public transport; more information about the project can be found in (Vinnova, 2009). Specification and alignments of the three public transport lines, the detailed background information and numbers as well as their geographical locations have been left out of this paper, as the planning and assessment is ongoing and details are not yet to be published (Vinnova, 2009).

### 4.1 DC layout – type 'Short: B'

The DC was planned as a half day intervention (4 hours). Stakeholders from the steering group of the transport planning group were invited alongside other interested parties with relation to the planning and development of the area. The invited participants were all professionals working in different departments regarding planning and development and the municipality. At first it was difficult to get the stakeholders to participate, but at the end 11 persons had accepted the invitation. As there were only four hours available for the DC and as there was envisaged a large number of participants the programme had to be carefully planned and focused on the key questions relating to the decision problem. The facilitator and the model technician decided for a programme focusing on the finding and definition of different criteria used for the evaluation. The specific focus on the choice of criteria and their definition were planned to contain a part where the participants were set to work out detailed descriptions of each criterion. The programme was designed using some creative elements where the participants had to undertake an active role in order to state their opinion.

In order to fit the time frame of the DC a set of key elements was chosen and a number of 'back-up' tasks were designed as well – these tasks could be left out in case of limited time or taken in if ahead of schedule. It was decided that it was better to have a tight schedule and pass through all the elements, rather than having a looser schedule with fewer elements. This ensured the maximum output for the participants, as one of the main goals was for these to feel an added value after the intervention. This choice was expected to influence the facilitation style. In worst case the facilitation would not be facilitation but rather meeting coordination, ensuring that all tasks were met at approximately the planned schedule. It was pointed out that the facilitator due to the time constraint stayed neutral and facilitated that all participants got a chance to state their opinion and that an agreement was sought, (Vidal, 2006b). The affect of the time constraint is expected to be shorter discussions where the content is not as in depth as it could have been if there had been more time available. The facilitator will have to ensure progress during all four hours. In a case where consent cannot be obtained, different methods must be implemented and the group must either be split and facilitated in two parts or two sets of output must be obtained.

The DC was held on the 20th of April 2009 from 8:15 am to 12:15 am and was carried out at the work place of the involved steering group. This location was chosen as it would be convenient for the participants and because it could be combined with the steering group having a regular meeting afterwards. The combination of having the DC in the morning and the steering group meeting at the same place after lunch enabled more participants to be present, and gave the participants the opportunity to use the output from the DC straight away and as inspiration for their tasks.

### 4.2 Case 2 - process evaluation

The DC applied in Case 2 was planned as a DC type 'Short: A' or 'short: B' as the steering group made it clear from the start that they only had half a day available for the intervention. All relevant experts/professionals in the steering group and related to the steering group were invited to participate in the DC. At first the registration for the DC was very slow, but at the end 11 persons had accepted, and 10 showed up on the day, and the DC could therefore be classified as a type 'Short: B'.

As the steering group had a profound wish to work with the criteria and the analysis, they had all ready preformed, focus was put on the criteria definition and prioritising, though there was a tight time constraint. This was possible due to only having three alternatives which would minimise the amount of pairwise comparisons substantially. The decision model can handle a maximum of ten criteria to be part of the pairwise comparison. The participants chose to use all the criteria and with 3 alternatives this resulted in 30 pairwise comparisons. In order to complete the whole DC within the time limit and with an increased focus on the criteria, the DC was facilitated in a more 'tough' way than is normally the case. This meant that the participants were not given all the time they could use for in-depth discussion of all issues. In this way the DC could be regarded as structured and controlled tending to be more of a structured meeting based on the values and using all the principles of a DC. The facilitator stayed impartial, but urged the participants to reach agreement when this was necessary to keep up with the time. Furthermore the participants decided to use some criteria which had been outlined as having some kind of overlap with the CBA, and which should have been reformulated to ensure that double counting was not taking place. This was pointed out by the facilitator and the process was based on the participants' choice of including them anyway.

Even with the tight time constraint the participants generally felt that their statements were listened to and that they were part of the discussion and all felt related to the conducted group result. At the end of the DC it was clear that if there had been more time available, especially the section considering criteria definition could have been improved. The participants experienced a few difficulties in the pairwise comparisons as the criteria had been defined too

broadly and in some circumstances they were pointing in opposite directions when assessing two alternatives against each other. After having thought a bit about the DC and started processing the inputs from the intervention, some participants felt that there might be some relevant criteria which had not yet been defined, and they considered this as very important information for their work. More time for criteria definition and description could have supported this matter. The pairwise comparison went very well under the time constraint. Not having more than 3 pairwise comparisons for each criterion helped the participants to stay focused during the whole process and not lose interest.

The entire DC was aided by several paper materials, some placed on the table at arrival and others handed out when needed during the intervention. Especially the use of self-adhesive posters which the participants could fill in at the table and which afterwards were placed on the wall was very helpful for the participants and enabled the facilitator to shift between processes around the table and processes, where the participants had to stand near the posters hanging on the wall. This change provided an opportunity to have different participants taking the lead in the discussion, so one 'strong' participant would not get both the first and the last word on every subject.

The DC proved to be very productive and the participants afterwards stated that they were very pleased having had some new input on how to work with the criteria and how the monetary and non-monetary criteria could be produced into a combined attractiveness measure based on their debate. The participants stated that they would have liked to have more time for the DC but not necessarily much more time, as not all believed that much more time would result in much better results, and that it would be easier to schedule a one day meeting, rather than a 2-3 days meeting.

With regard to the four DC layouts outlined, case 2 underlines that it was possible to get a result from a DC type 'Short: B'. It furthermore sets focus on the effect of having a large number of participants and a time constraint of 4 hours. With the obtained knowledge the participants would have chosen a one day intervention. In case 2, the DC to a large extent served as an inspiration and eye-opener for the steering group providing them with a screening of the preliminary results and focusing on where more work could be beneficial for the planning and decision making process.

## 5. Discussion

Application of the DC types 'Short: A' and 'Short B' in cases 1 and 2 has shown that these DC types are applicable and helpful when dealing with large transport decision problems as they both served well to inform the decision makers. Both applications were conducted under

a time constraint limiting the possibility for improvisations and lengthy debates. This to some extent influenced the DCs, but not to an extent where it was considered a problem. A participant from case 2 stated that 'a little more time would be useful, but much more time would not necessarily lead to much better decisions'. Based on these experiences it could be argued that a one day DC layout starting at 9 am and lasting to 4 pm with a 45 min lunch break mid-way and short breaks, whenever needed, can be recommended. It has though proven difficult to engage many busy stakeholders with tight schedules for more than half a day if they are not familiar with the concept of DC. The two applications have furthermore proven that half a day is the minimum amount of time in which a DC can be conducted, and that the participants after a half-day intervention would be willing to spend more time. More than one day is on the other hand assessed to be too much, if the number of participants is between 2 and10, as there is a possibility that not all participants will show up each day and that they might lose interest if they get the feeling that the DC is too time-consuming compared to the outcome. Furthermore, a one day intervention is easier to fit into the participants' calendars as it does not seem too long to take one day out for an intervention. If more days were considered, then provision of accommodation for the participants, the facilitator and the model technician would be recommendable as everybody would stay in the same place and within the context, this having several advantages, but also the disadvantage of the increased cost and time use.

The choice between either experts/professionals or all stakeholders can be used for obtaining different goals. Having only experts/professionals participating in a DC can be recommended for either a scanning process or for a validation of a set of selected criteria as described in the validation of the EIA in case 1. On the other hand a DC with all stakeholders can be used as an input to a public hearing based on the invited participants and a structured debate. For this it could be recommended that the layout contains both experts/professionals and affected stakeholders and a total of 8-10 participants in order to obtain the best possible debate around the table, where all participants have equal right to state their opinion and the forum enables everybody to see and hear each other. A maximum of 10 participants will also enable the facilitator to easily apply tools and methods which seem appropriate based on the development of the debate if the participants need help to keep the debate moving.

The number of alternatives considered in the decision problem has great influence on the DC process. In case 1, a total of 48 pairwise comparisons were conducted and in case 2 the number was 30 even though more criteria were considered. The influence which the number of alternatives has on the process should be considered when the DC is designed, as many alternatives result in many pairwise comparisons, which take up much time and energy from the participants. The number of alternatives to take into consideration should be based on the

outline of the decision problem, the available time and the number of participants and the focus of the DC. Based on the decision model in use the minimum number of alternatives is three and the maximum six or seven. The number of included criteria has not got as great an influence on the time composition during the pairwise comparisons as the number of alternatives and the decision model can process one to ten criteria dependent on the participants' choices.

Common for each of the four proposed DC types is that they are all based on customisation to the given problem situation. The length of the preparation phase and the number of meetings or even small preparation workshops that will be needed depends on the state of the problem situation and the existing material regarding the case.

This paper also proposes that a participative method such as a DC can be used to operationalise the concept of sustainability with regard to the planning process. Jeppesen (2009a) argues that the concept of sustainability can be used either implicitly or explicitly. An explication and operationalisation of the concept of sustainability with regard to the social, economic and environmental dimension in relation to the transport planning process and not the specific result can be obtained by use of a DC. Participation of involved and affected stakeholders in the decision process can be regarded as an explication of social sustainability as every stakeholder, no matter if they are the decision makers or not, will have an opportunity to state their opinion during a structured debate. The use of several alternatives and CBA can be regarded as an explication of economic sustainability as this incorporates the different solutions and their monetary impacts, and allows for a prioritising based on monetary issues. Finally the use of non-monetary criteria can be regarded as an explication of environmental sustainability as it provides the opportunity to bring in all the effects and effected areas which are not included in the CBA. The concrete use of non-monetary criteria, also considered as wider economic impacts, provides an opportunity to not only base assessments on direct monetary values, as the non-monetary effects can be put forward in a way comparable to the monetary effects. This is of importance for transport planning where both a number of worldviews, strategies and visions can be lined up and where a number of alternative solution proposals are often found. Involvement of stakeholders in the process represents a participative approach to decision making. The participating stakeholders might have very different backgrounds, and levels of knowledge and not all get to influence the final decision, but they can get the opportunity to state their opinion, and influence both process and decision makers.

## 6. Conclusions and perspectives

The concept of DCs proved to be useful when dealing with complex transport planning situations as described in cases 1 and 2. The DC enables a structured debate between stakeholders who could either be involved in and/or affected by the decision. DCs can be a tool for transport planners to ensure stakeholder participation within the transport planning process and the following decision making.

Four DC types named 'Short: A', 'Short: B', 'Standard: C', and 'Standard: D' have been outlined in order to accommodate combinations of the three indentified parameters, number of participants, type of participants, and available time. 'Short: A' and 'Short: B' are designed as a variation of the 'Standard' approach provided in the literature, and they are altered to be more applicable in a transport planning context where time and resources often are constrained. The proposed DC types can be used for different setups depending on the task and the stage in the planning process the DC is implemented. It can be recommended to use DC types based on a layout which can be conducted as a one day intervention. This makes the intervention more accessible for the participants as the time use will not exceed what can usually be granted for this kind of purposes. A main finding is that the standard DC (types C and D) should be supplemented with the short DC (types A and B) which has been found to be very useful and productive in the examined cases.

Implementation of DCs in the transport planning process allows for an explicit operationalisation of social, economic and environmental sustainability within in the planning process. This enables planners and decision makers to deal with this complex concept in an explicit and structured way.

The two described applications of DCs have both been conducted as part of a research project with very positive responses to the process, the outcome, and the usability of the concept. The research project setups have been very close to 'real-life' applications with the only difference that the DC was not ordered by the problem owner but proposed to the problem owner as an opportunity to learn about the process and gain information for the ongoing planning and decision processes. All participants have responded in a positive way to the use of DC and to the suggestion that it could be a regular part of the planning process. One simple indication of the usefulness of the DC is that the participants expressed that they would like to participate in similar interventions.

## Acknowledgements

The two applications of DCs referred to in this paper were conducted as part of the Vinnova research project, and I would like to thank all the participants in the two DCs, and my colleagues in the project for their interest and our shared effort during the interventions.

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## *4.10 Overview of paper 5*

### *Exploring an explicit use of the concept of sustainability in transport planning*

| | |
|---|---|
| Title: | Exploring an explicit use of the concept of sustainability in transport planning |
| Author: | Jeppesen, S. L. |
| Submitted: | For an international journal in November 2009 |

**Paper description**

This paper seeks to explore an explicit use of the concept of sustainability within transport planning. A concrete planning situation is used as reference for the exploration. The reference case regards the development of the Nordhavn area which is a part of Copenhagen, where the visions have a strong focus on the three dimensions (social, economic, and environmental) of the concept of sustainability.

The planning situation is explored using SSM. The findings from SSM are related to different levels of planning outlined by Ulrich (1988). Based on these inputs and the need for participative processes, a set of stakeholders are identified and invited to participate in a semi-structured interview based on the CSH questions. This has led to inputs which are used to outline some initial guidelines for how the concept of sustainability can be operationalised in transport planning.

**Main findings**

Application of SSM in the concrete planning case and the exploration on how the concept of sustainability can be explicated in the concrete situation lead to some main findings. These findings regard how the concept of sustainability is or can be used in the planning and that there is a need for recognising different applications areas of the concept either relating to the process or to the results.

It was chosen to focus the exploration of the concept of sustainability on an application to the process. For the semi-structured interviews based on CSH four categories of stakeholders were identified: 'citizen', 'NGO', 'professional' and 'expert'. The interviews focused on what a sustainable transport planning process is, and some of the key points from the interviews are presented in a summarised way, see Table 31.

| Citizen #1 | Citizen #2 | NGO | Professional | Expert |
|---|---|---|---|---|
| • Focus on the users, both in planning and goals<br>• Use committees with somebody who knows about the subject<br>• Participation by locals affected (e.g. by a 'court-case) | • Focus on the experts during the planning process<br>• Use existing experience, knowledge and statistics<br>• Long-term planning (future proof solutions) | • Proposal of 'new' and 'better' alternatives<br>• Holistic planning and interaction across transport sectors<br>• Creation of a 'sustainability directorate' situated directly under the Danish government | • Stakeholder participation and creation of public and local ownership<br>• Flexibility, robustness, and transparency in plans<br>• All dimensions of the concept of sustainability | • First the professionals then the decision makers<br>• Long-term planning in a 'short-term' world<br>• Find the right 'levels' to introduce on – and introduce on all relevant levels |

**Table 31 The three most essential key points made by each of the stakeholders in the five CSH-based interviews, adapted from (Jeppesen, forthcoming)**

The planning levels outlined by Ulrich (1988) are following compared to the planning levels in Danish transport planning. In general the national level is associated with ideal-planning and the municipal level with goal-planning. For the Nordhavn case it is found that the Municipality of Copenhagen has chosen to act both as ideal-planners and as goals-planners as they both design the ideals and provide the guidelines for the subsequent goal planning which they also define and conduct. Based on these inputs a set of guidelines for how the concept of sustainability can be operationalised in regard to 'process' has been outlined, see Table 32.

| What | Why |
|---|---|
| Ask and include the users | About their needs and wishes |
| Use the experts and prior experience | Give them as much influence as possible |
| Follow the democratic process | The elected persons get the last word |
| Make measure and control considerations | To keep focus on the visions |
| Transparency in the process | To ensure a fair process which is clearly described and argued |
| Stakeholders | Identification and involvement of both involved and affected stakeholders |
| Participation in design and decision making | Listen to the users before, during, and after the planning process |
| Alternatives | Identify both obvious and more unconventional possibilities |
| Criteria | Use both monetary and non-monetary criteria in the assessment |
| Visions | For robust long term planning and flexibility |

**Table 32 Initial input for development of guidelines for definition of a sustainable transport planning process based on the five CSH-based interviews with selected stakeholders, adapted from (Jeppesen, forthcoming)**

The findings of this paper are seen as an initial step towards an explicit use of the concept of sustainability in the transport planning 'process' and it is demonstrated that SSM and CSH are valid methodologies for exploring the use of sustainability in transport planning and that CSSF can be used in further development of the presented case study.

## 4.11 Paper 5 Exploring the concept of sustainability

**Exploring an explicit use of the concept of sustainability in transport planning**

*Submitted for an international journal in November 2009.*

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**Abstract**
The aim of this paper is to explore an explicit use of the concept of sustainability within transport planning. This paper analyses the concept of sustainability based on a practical approach for a sustainable development of Nordhavn, an area of Copenhagen. The case is used as reference point and exemplifies a complex planning problem and transport planning. An exploration of the concept of sustainability is carried out using Soft Systems Methodology (SSM). This approach indicates a need to separate the use of sustainability considerations regarding the 'process' from the considerations of the 'results', and it was chosen to focus on the understanding of a sustainable process. The focus thereby set upon the process as relating to sustainability is addressed by four stakeholder groups interviewed based on the 'ought to' mode of Critical Systems Heuristics (CSH). Finally an outline of some of the factors of a sustainable planning process is proposed.

**Keywords**: Implicit/explicit sustainability, 'process'/'results', Soft Systems Methodology (SSM), Critical Systems Heuristics (CSH).

### 1. Introduction

When an area is going to be developed, there is a number of issues which need to be considered, e.g. land-use, urban design, and design of the infrastructure including the transport system, etc. These issues regard, among others, the purpose, the process and the results. These issues can all be related to visions for the development and are constrained by available resources. In this paper an operationalisation of the concept of sustainability is addressed in relation to development of a new urban area. The main focus is upon the meaning of the notion 'sustainable transport planning'. In the applied case of Nordhavn, which is used as a reference, there is a vision stating that the area is supposed to be trend-setting in terms of making new standards for sustainability (CPH, 2008a). Sustainability is often defined as having three dimensions: the social, the economic, and the environmental (UN, 1987). In transport planning the concept of sustainability has been around for several years, but it is

unclear what it really means and regards, and therefore it sometimes appears as just a 'nice' word. There is often a tendency to focus only on the 'green' part (environment) of the concept of sustainability, thereby relying only on one of its three dimensions.

In traditional transport planning the concept of sustainability is often used in an implicit way, where the norms and values concerning it are not specifically stated. This means that the content of the concept of sustainability is often not firmly articulated and that there can be different understandings of how, when, and where it is applied, monitored, and controlled. Jeppesen (2009a) has proposed that sustainability considerations are made more explicit. This can be done in different ways. Jeppesen (2009a) proposes a scanning tool which can be used in the early phases of a planning and decision making process. This approach explicates a 'sustainability strategy' defined by a so-called 'sustainability advocate' which is present during the whole process and which is developed around a set of clearly defined key values. Jeppesen (2009b) furthermore proposes the use of decision conferences (DC) in transport planning in order to explicate the three dimensions of the concept of sustainability within the transport planning process. It is argued that DCs can help to explicate the dimensions of the concept of sustainability, respectively (Jeppesen, 2009b):

- The social dimension by participation of involved and/or affected stakeholders
- The economic dimension by considering several alternatives and the use of monetary measures such as benefit/cost-rates (B/C)-rates
- The environmental dimension by using non-monetary criteria covering other relevant issues

The two approaches outlined by Jeppesen (2009a, 2009b) are both argued to be explicit, transparent and applicable in the transport planning processes. The aim of both approaches is to operationalise the concept of sustainability in transport planning by altering the traditional implicit use to an explicit use. This change from implicit to explicit use is a main focus of the paper.

The paper is structured as follows. After the introduction, the second section describes the case of Nordhavn, which is used as a reference for understanding how the concept of sustainability can be operationalised. The third section describes how the development of Nordhavn is analysed. SSM is used to structure the problem situation with regard to understanding what a sustainable development of Nordhavn is and reveals that it is important to know what part of the planning the concept is applied to. The fourth section outlines the initial ideas regarding whether the concept should be applied to either the process and/or the result, and the differences are discussed. The two different approaches are related to four planning types

presented by Ulrich (1988). The fourth section outlines what a sustainable process could be like and some guidelines which can be used for an operationalisation of the concept of sustainability are presented. CSH is used to define the content of such a process, using it in its normative form for five semi-structured interviews with members of four identified stakeholder groups. The fifth section discusses the initial ideas and results from the case study in Nordhavn, and finally the sixth section concludes on the preliminary findings regarding what a 'sustainable transport planning process' is.

## 2. Reference case: Nordhavn

Nordhavn is an area of Copenhagen which until now has been used as a conventional industrial harbour with a container terminal. The area also houses a fishing harbour, the fish market of Copenhagen, a cruise terminal, and a range of companies etc. Recently it was decided to develop this area for housing and post-industrial companies. The aim is to make room for up to 40,000 inhabitants and 40,000 jobs by increasing the existing Nordhavn area of 200 ha by further land fillings. The development is planned to undergo different phases and will not be completed until 2050. The municipality of Copenhagen will be forming the guidelines for the development in cooperation with Copenhagen City and Port who manages the land and handles sales and contracts with potential developers (CPH, 2008a). A number of political founded visions have been outlined for the development of the area. The most important vision related to the development of Nordhavn is that Nordhavn should be a 'lighthouse' project regarding sustainable urban planning, and that it should form a trend-setting example with regard to both economic, social, and environmental sustainability. Specifically regarding transport, the vision is to have a minimum 1/3 of the transport conducted by walking/cycling, a minimum 1/3 of the transport conducted by public transport, and a maximum 1/3 of the transport conducted by car, (CPH, 2008a).

Another important part of the planning in the Nordhavn area has been an extended amount of information and public (stakeholder) participation. Several public meetings were held prior to the start of the planning process and the information gained at the meetings was used to inspire the process and the programme for the architectural competition which was held in 2008 regarding design of the master plan for the area. The winning consortium will be acting as Copenhagen City and Harbour's advising consultant regarding the development of Nordhavn (CPH, 2008a, 2008b). Throughout the process, and after selection of a winner of the architectural competition, the open process with public participation by stakeholders has continued in order to ensure openness to questions and ideas from involved and affected stakeholders.

Below the paper deals with the case of Nordhavn and explores some issues that are relevant to consider for an operationalisation of sustainability in transport planning.

**3. The concept of sustainability related to the planning task**

Khisty & Leleur (1997) and Kane & Mistro (2003) have suggested Soft Systems Methodology (SSM) as a relevant methodology when dealing with complex transport problems. Jeppesen (2009c) has indicated that systems thinking could be beneficial for dealing with the concept of sustainability in transport planning. The case of Nordhavn can be described as both complex and strategic. To understand the planning task and how it related to the three dimensions of the concept of sustainability, the visions and the development are explored using SSM as developed by Peter Checkland, (Checkland, 1993/1999) and (Checkland & Poulter, 2006). SSM is applied in a semi-soft way, where the soft methods are applied solely by the analyst and based on the existing information (Jeppesen et al., 2008). The analysis is therefore conducted by the author without further participation, but as an approach to understand the situation and the concept of sustainability seen from a researcher's perspective.

SSM is first used to structure the problem situation, regarding a sustainable development of the area of Nordhavn, see focus No. 1 in Figure 37 displaying a 'rich picture' which indicates that the case is both strategic and complex, and that there are many concerns and constraints. Five main challenges were identified:

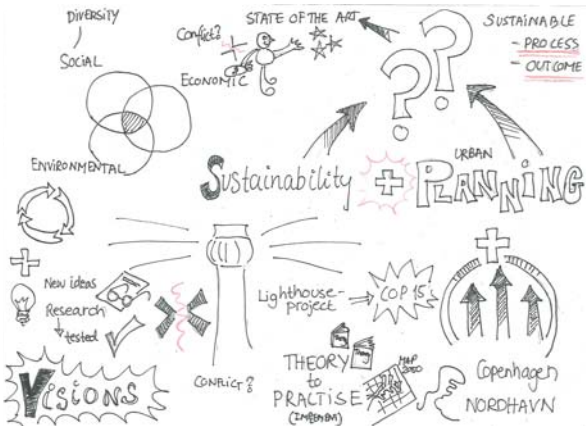
- *Understanding how the concept of sustainability is or can be used in the planning*
- *Defining how to keep the concept a key value in the development*
- Implementation of the vision of being trend-setting (yet possible) in the area of sustainability
- Open-ended parameters in the development of the area
- Many wishes and ideas

The two bullet-points in italic were chosen for further analysis as they were seen as key points in an explication on the concept of sustainability in transport planning. The focus was placed on how to define a system providing measures and controls to ensure sustainable planning. Based on the rich picture several root definitions, conceptual models, and CATWOEs were conducted as well as an analysis 1. On this background four main findings were made:

- There are many actors and stakeholders (both involved and affected)
- There is a lot of activity – huge interest on the public meetings held
- There is a need to find methods to ensure sustainable planning
- *There is a need to understand the meaning of the concept of sustainability*

The initial exploration of the problem situation led to refocusing of the problem situation into an exploration of what sustainable planning is and how the concept of sustainability is understood (see the above bullet-point highlighted in italic), see focus No. 2 of Figure 37.

Focus No.1: The Nordhavn planning situation



Focus No. 2: Sustainability and planning in Nordhavn

**Figure 37 The Nordhavn case is strategic and complex: Case outlined by sketching and keywords (using SSM 'rich pictures')**

Focus No. 2 is about how to understand the concept of sustainability with regard to (transport) planning. From the sketched rich picture further information was gained in order to sharpen the problem focus. The main challenges in this approach were defined as:

- *What does 'sustainable planning' mean?*
- What is the relation between visions and possibilities (economic or other constraints)?
- How to assess and use new ideas (untested) as opposed to more 'traditional' solutions?
- How to get from theory to practice?
- What are the differences of a sustainable process vs. sustainable results?
- How to deal with the possibility of either sustainable or non-sustainable outcome (results)?

From these the term 'sustainable planning' (the bullet-point highlighted in italic) were identified as the most important for further analysis. Application of root definition, conceptual models and CATWOE to explore and define a system enhancing the understanding and use of the concept of sustainability revealed four key points that can be described as follows:

- There is a need for obtaining a better understanding of the concept
- There is a need for exploring the concept of sustainability further
- There is a need for an operationalisation and explication of the concept

- *There is a need for recognising different application areas of the concept, either relating to the process or to the results*

The SSM application thereby indicated that there is a difference in whether the concept of sustainability is applied to the (transport) planning 'process' or to the outcome of the (transport) planning, the 'results', see the above bullet-point highlighted in italic. Such a distinction indicating where the concept is applied is seen as relevant in relation to an explication and operationalisation of the concept of sustainability in transport planning as it provides different views on how the concept can be used and applied to different levels of the planning procedures.

The operationalisation of the concept of sustainability as relating to different levels can be illustrated by a planning type scheme worked out by Ulrich (1988) based on ideas of Churchman. In this scheme Ulrich sees the process of unfolding a problem situation and its boundaries as crucial in relation to *"the art of making 'the problem' the problem"* (Ulrich, 1988, p. 415) as he states that *"almost everything planners do is related to their understanding of the problem"* (Ulrich, 1988, p. 415).

Ulrich (1983, 1988) describes the process of unfolding as actually yielding maps of the situation in question. Using the 'is' and 'ought' mode of Critical Systems Heuristics (CSH), for a brief introduction see (Ulrich, 2005), a map of the actual situation and a map of the ideal situation can be constructed using 'actual-mapping' or 'ideal-mapping', respectively. In this relation Ulrich (1988, p. 427) outlines four planning types which can be found in both the actual and the ideal mapping, respectively. The four planning types are here outlined according to their actual and ideal mapping content, see Table 33. The ideal mapping is systemically combined with the actual mapping in an iterative, unfolding scheme (Ulrich, 1988). This scheme will not be pursued in this paper as the focus here is set upon the planning levels and the task and constraints that can be applied unfolding the notion of sustainable planning.

| Planning type | Actual mapping | Ideal mapping | |
|---|---|---|---|
| | Planning task | Planning constraints | Planning level |
| Ideal-Planning | Design ideals | Ideals, purposes, goals, and means sought | Normative |
| Objective-Planning | Determine the planning purposes to secure improvement | Ideals given, purposes, goals, and means sought | Strategic |
| Goal Planning | Define exact goals that will secure improvement | Ideals and purposes given, goals and means sought | Tactic |
| Means Planning | Means | Ideals, purposes, and goals given, means sought | Operational |

**Table 33 Overview of the four planning levels and two mapping types outlined by Ulrich (1988), adapted from (Ulrich, 1988, pp. 425-427)**

The planning levels defined by Ulrich (1988) reflect the areas of concern for the different planning types and the boundaries under which the planning is conducted. 'Ideal-Planning' is seen as the highest abstraction level of planning where design ideals are sought, and 'Means Planning' is seen as the lowest abstraction level as ideals, purposes, and goals are given, and only the means are sought. With regard to the focus of exploring sustainability, 'process' can be related to ideal planning and 'results' to goal planning. These planning levels can be associated with the actual levels in Danish transport planning, as transport planning in Denmark is conducted mainly on the national and the municipal level. Principally, the national level ought to be concerned with both ideal and goal planning, setting out the vision about sustainability in transport planning and conducting this on areas where the national level is the authority. Following this, the municipal planning ought to be concerned with planning about goals based on the ideal designs made on the national level, but could also contribute with ideals that are missing or are even more ambitious than the ones set out at the national level.

This paper has its focus on the ideal planning level. However, neither ideals, purposes, goals, nor means are given beforehand. The remainder of this paper will address these 'process' issues as relating to sustainability within the transport planning 'process'. If focus had been on the 'results', the use of indicators based on the ideals, etc. could have been treated.

In relation to the development of Nordhavn the Municipality of Copenhagen has chosen to act on what is here described as the level of ideal mapping as it both designs the ideals (e.g. for the split of transport modes, described by the three 1/3 descriptions of the transport modes, see section 2) and provides the guidelines for the subsequent goal planning based on the master plan and the input from the appointed advisers found in the architectural competition.

**4. Exploring what a sustainable transport planning process is**

Banister (2008) describes the sustainable mobility paradigm as in need of a series of consistent policy measures and as moving towards an objective-based planning system based on stakeholder support (Banister, 2008). Banister concludes that there is a need for empowering stakeholders and for formation of broad coalitions consisting of all stakeholders related to all areas of transport if a real debate regarding how sustainable mobility is to be obtained. Ulrich (2000) points out the importance of responsible citizens and the necessity of including citizens in the critical reflection of a planning process. He claims that citizens can help to question the consequences that the actions of the professionals impose on them. On this background I identified in the Nordhavn case a set of stakeholders with varying backgrounds and worldviews (citizens and professionals) to help clarifying and describing what a sustainable transport planning process could be like. Specifically, four generic groups of stakeholders were invited to participate. They can be described by the categories: 'citizen', 'NGO',

'professional' and 'expert', the three latter each with the prefix 'transport'. The stakeholders were selected so they represented both the involved and the affected ones. They were asked to participate in a semi-structured interview based on the questions outlined by Werner Ulrich in Critical Systems Heuristics (CSH), (Ulrich, 1983, 2005). The questions were only asked in their normative 'ought to' form searching in this context for some generic answers regarding the interpretation of a sustainable transport planning process. The CSH questions were asked so they fitted into the conversation. Thus questions were made dependent on the development of the conversation and therefore not necessarily all questions were asked. I conducted the semi-structured interviews in the period from April to August 2009.

The CSH questions were as mentioned only asked in the normative ought to mode. The general areas of concern, ideas, and initiatives relating to the 'ideal' of a sustainable transport planning process brought forward by the stakeholders were summarised by the author. Each participant's answers were shortened and interpreted by me in order to provide an overview of what they each commented on in relation to providing a sustainable transport planning process. However, it should be noted that the participants gave answers containing longer explanations and several examples, some more than others, not accounted for here. Three key points made by each of the stakeholders in the five CSH-based interviews are highlighted and shown in Table 34.

| Citizen #1 | Citizen #2 | NGO | Professional | Expert |
|---|---|---|---|---|
| • Focus on the users, both in planning and goals<br>• Use committees with somebody who knows about the subject<br>• Participation by locals affected (e.g. by a 'court-case) | • Focus on the experts during the planning process<br>• Use existing experience, knowledge and statistics<br>• Long-term planning (future proof solutions) | • Proposal of 'new' and 'better' alternatives<br>• Holistic planning and interaction across transport sectors<br>• Creation of a 'sustainability directorate' situated directly under the Danish government | • Stakeholder participation and creation of public and local ownership<br>• Flexibility, robustness, and transparency in plans<br>• All dimensions of the concept of sustainability | • First the professionals then the decision makers<br>• Long-term planning in a 'short-term' world<br>• Find the right 'levels' to introduce on – and introduce on all relevant levels |

**Table 34 The three most essential key points made by each of the stakeholders in the five CSH-based interviews**

The concerns of the four stakeholder groups can be combined into an initial outline of how a set of guidelines for a sustainable transport planning process, see in Table 35, and an initial input for sustainable transport planning result can be set out, see Table 36. These guidelines are based on the inputs from the stakeholders and can be seen as initial input for proposing a design ideal for a 'sustainable transport planning process'. The stakeholders provided several concrete ideas for how participation could be encouraged and further developed. These ideas are not presented here. The outlined key statements of elements for a sustainable planning

process can be supported and developed by the findings of Jeppesen (2009a, 2009b) where some of the same elements were identified in combination with elements as the importance of using both monetary and non-monetary criteria in the assessment and decision making process.

| What | Why |
|---|---|
| Ask and include the users | About their needs and wishes |
| Use the experts and prior experience | Give them as much influence as possible |
| Follow the democratic process | The elected persons get the last word |
| Make measure and control considerations | To keep focus on the visions |
| Transparency in the process | To ensure a fair process which is clearly described and argued |
| Stakeholders | Identification and involvement of both involved and affected |
| Participation in design and decision making | Listen to the users before, during, and after the planning process |
| Alternatives | Identify both obvious and more unconventional possibilities |
| Criteria | Use both monetary and non-monetary criteria in the assessment |
| Visions | For robust long term planning and flexibility |

**Table 35 Initial input for development of guidelines for definition of a sustainable transport planning process based on the five CSH-based interviews with selected stakeholders**

| What | Why |
|---|---|
| Aim at flexible, dynamic, and ever-changing plans | So they can follow the development of society, ways of living etc. |
| Aim at lasting and robust plans | The decisions should be long-term and there should be no need for removal of first phase constructions in late phase of designs and ideas |

**Table 36 Initial input for development of guidelines for definition of a sustainable transport planning result based on the five CSH-based interviews with selected stakeholders**

The initial inputs to design of a sustainable transport planning process where the concept of sustainability is operationalised and explicated can be seen as input on the ideal-planning level providing design ideals. In order to ensure that these normative design ideals are met by the lower levels of planning involving the strategic, tactic and operational levels outlined by Ulrich (1988) it is important to obtain a set of tools which can provide the ability to measure and control if the ideals are fulfilled.

When the focus is on the 'process' and the ideal mapping, the tools of conceptual modelling and the 5 'E's' of SSM (efficacy, efficiency, effectiveness, elegance, ethicality) can be used, for further description see (Checkland & Poulter, 2006). The conceptual models can be used to examine the decision process and the participation, and the 'E's' can be used for monitoring and control. Especially E1-efficacy, E3-effectiveness, and E5-ethicality are of interest with

regard to a sustainable transport planning process as they regard achievement of the intended outcome, achievement of higher-level long-term goals, and the morality of the transformation process (Checkland and Poulter, 2006 pp. 42-43). For monitoring and control of the outcome in terms of the 'results', more specific tools can be applied. Several specific 'sustainability tools' have been developed by actors in a variety of sectors. The Municipality of Copenhagen has e.g. implemented the use of a 'sustainability tool' in the Nordhavn development, (KK, 2009). This tool is used on the plans which were part of the architectural competition regarding a design of a master plan for the area. The sustainability tool is here applied on the municipal level and will be used throughout the Nordhavn development process. Such predefined tools are fixed to a certain set of indicators evaluating the results – in this case the master plans. The tool is thereby linked to goals, and goals planning.

For an operationalisation of the concept of sustainability as ideal planning, the conceptual models and the 'E's' will be helpful whereas more specific 'sustainability tools' will be helpful for goal planning. Development of Nordhavn can be seen as acting on both the level of ideal planning and the level of goal planning. Other tools to monitor and control the process might also be necessary. These can be determined by an actual monitoring and evaluation of the Nordhavn development process over the next up till 50 years.

## 5. Discussion

The use of SSM to structure and understand the problem situation indicated that in order to operationalise and explicate the concept of sustainability it is relevant to clarify if the concept is applied to the process or the results. It can be discussed if a distinction can be made between 'process' and 'results'. Some might argue that they cannot be divided or that sustainable results cannot be obtained without a sustainable process. In this paper this question has been dealt with by exploring two approaches to applying the concept of sustainability in transport planning, as it is perceived that the two described areas of application, process and results, can be dealt with individually depending on the chosen planning level.

With an operationalisation of the concept of sustainability with regard to the process the focus has been on making the concept explicit and transparent. Furthermore it has been of importance to ensure explication of all three dimensions of the concept. Jeppesen (2009a & 2009b) has indicated two approaches to such an application based on the Decision Simulation Technique and Decision Conferences, respectively. If the focus had been on the results, a set of indicators could have been used to explicate the concept.

To develop the understanding of what a 'sustainable transport planning process' is, CSH was used for semi-structured interviews held with several stakeholder groups. Though the outcome

had similarities the abstraction level of the concerned subjects and concepts were received very differently among the stakeholders. The present approach indicated that the concept of sustainability can be explored further by a participatory use of e.g. Critical Soft Systems Framework (CSSF) (Jeppesen & Paucar-Caceres, 2008). Application of CSSF combining SSM and CSH in a joint approach could have provided the participants with a broader possibility to explore the problem situation through an intervention where there would have been an opportunity to explore the situation further. This would provide for the critical reflection of CSH alongside the exploration and modelling, monitoring and control elements of SSM being obtained at the same time.

## 6. Conclusion

The concept of sustainability is often seen as a 'green attribute', but does actually consist of three dimensions: a social, an economic and an environmental. To understand and thereby operationalise the concept of sustainability with regard to transport planning, SSM has been used to explore the problem situation of operationalising the concept of sustainability in transport planning. This has indicated that it is relevant to approach the concept both with respect to the planning 'process' and the 'results'. The focus in this paper has been on the process as this is seen as the first step towards outlining a content of sustainable transport planning. The identified differences in a sustainable process and sustainable results were found using the outlined planning levels (Ulrich, 1988) and the planning actually conducted so far in the Nordhavn case. They indicated that it is important to clarify on what level the concept of sustainability is to be applied. It has been found that a sustainable transport planning process suits the highest planning level, the ideal-planning, whereas sustainable results suits on the lower goal-planning level. Though ideal-planning should be pursued by the governmental level, it could also be pursued on the municipal level, whereas goal planning relates to both the national and municipal level. In the Nordhavn case the municipal level conducts both ideal and goal planning at the same time. Based on a set of semi-structured CSH-based interviews some guidelines for a sustainable transport planning process have been outlined. These are seen as a first step for mapping the ideal-planning level and represent an initial step towards an explicit use of the concept of sustainability in the transport planning 'process'. By means of the Nordhavn case this paper has shown that both SSM and CSH are valid methodologies for exploring the use of sustainability in transport planning.

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# 5 Guidelines

This chapter suggests an outline of a set of guidelines regarding how an operationalisation of the concept of sustainability can be obtained. The guidelines are based on this thesis' work exploring an increasing understanding of the concept and its dimensions as well as of an understanding of the context where it is applied. Focus is therefore respectively placed on the problem situation, the process and the results, see 2.2.3 and paper 5 in section 4.10 and 4.11.

## *5.1 Outline of a set of guidelines for a sustainable transport planning process*

Based on the survey of probable methodologies and the case studies conducted in papers 1-5, a set of guidelines has been outlined in order to enable an operationalisation of the concept of sustainability within transport planning and decision making. It has been found that it is important to approach the planning process and the result in different ways in order to explicate the use of the concept of sustainability, see paper 5 (Jeppesen, forthcoming) in section 4.10 and 4.11. This PhD thesis has focused on sustainability in the planning process, but a few comments are made with regard to the results of the planning process as well. The important tasks have been found to be:

- Problem identification, understanding, structuring, and boundary judgements
- Identification of problem type and possible complexity level
- Identification and participation of involved and affected stakeholders
- Roles and relations between stakeholders
- Definition of monetary and non-monetary criteria
- Definition of probable alternatives with room for new ideas
- Considerations of power and control elements
- Monitoring procedures

Based on the findings and some of the important planning and decision making tasks, this PhD thesis has sketched a set of guidelines in order to explicate the concept of sustainability within the transport planning. The guidelines are divided into three tables, Table 37 - Table 39, the

first one considering the problem situation, the second one considering sustainability in the process, and the third one considering sustainability in the results. The outlined guidelines consist of a set of questions which is intended for the planners. The questions are accompanied by a suggested follow up, methodology recommendations or proposals of possible indicators.

The guidelines outlined in Table 37 are focused on the problem situation. The main purpose of the questions is to ensure problem understanding and structure, in order to determine whether or not the problem in focus is in fact the problem or just a symptom of the problem. Furthermore, the guidelines regard considerations of whether or not the problem is complex, and if it is indeed a complex problem, then what kind of complexities it regards. In Table 37 the existing methods, Litmus test, SSM, and CSH are among other suggested as support for the guideline questions.

| Task | Focus area | Question | Follow up and methodology recommendations |
|---|---|---|---|
| Problem situation | Problem definition | • Can the problem situation in question be stated in one short and very clear statement?<br>• Are there more than one problem, and if so, how are they related?<br>• Is the problem situation clear to all stakeholders? | • Rewrite and clarify if there might be more than one problem within the thought-to-be problem situation<br>• Use SSM |
| Complexity | Detail complexity | • Are the required data precisely predicted and easily obtained by 'traditional' systematic methods or is a systemic approach needed? | • Use Litmus test |
| | Dynamic complexity | • Does this problem situation change over time and how? | • Use Litmus test<br>• Related to short/long term planning |
| | Preference complexity | • Who are the stakeholders and what are their worldviews and opinions? | • Use Litmus test<br>• Use CSH |

**Table 37 Guideline questions regarding the problem situation, and suggested follow up and methodology recommendations**

The guidelines outlined in Table 38 regard an operationalisation of the concept of sustainability in the planning process. The three dimensions of the concept of sustainability is outlined and related to the planning process by the guideline questions. In order to follow up

and to work with the questions, three of the four methodologies (CSSF, DST, and SDCs) which have been proposed in this PhD thesis have been recommended as helpful in the operationalisation of sustainability in the planning process. Semi-Soft methods can also be used if participation is not possible.

| Task | Focus area | Question | Follow up and methodology recommendations |
|---|---|---|---|
| Sustainable process | General considerations | • Are prior knowledge used and visions followed?<br>• Are measure and control considerations made?<br>• Is there transparency in the process? | • Decide for an implicit or explicit use of the concept of sustainability<br>• Use CSSF, DST, or SDCs |
| | Social sustainability | • Is participation sought?<br>• Is participation only used as a process to inform and clarify?<br>• Who is participating where in the process?<br>• What is the participants' influence level?<br>• Is the use of the concept of sustainability made explicit, transparent and understandable to all stakeholders? | • Use CSSF, DST, or SDCs |
| | Economic sustainability | • Are there any alternatives, and are they good enough?<br>• Is the quality of the data regarding monetary criteria good enough? | • Use CSSF, DST, or SDCs |
| | Environmental sustainability | • Are all relevant non-monetary criteria considered, described and prioritised?<br>• Under which worldview and by who are the criteria defined? | • Use CSSF, DST, or SDCs |

**Table 38 Guideline questions regarding a sustainable process, and suggested follow up and methodology recommendations**

The guidelines outlined in Table 39 regard an operationalisation of sustainability in the result. The three dimensions of sustainability have also been addressed in regard to the results. The guideline questions contain the definition of the goals and the indicators used to evaluate if the goals have been fulfilled. These indicators are formed in order to follow up on the sustainable planning process and its goals.

| Task | Focus area | Question | Follow up and methodology recommendations |
|---|---|---|---|
| Sustainable results | Social sustainability | • What are the goals, and are they short or long term?<br>• Which values, norms, and worldviews are the goals based upon?<br>• Are the goals fulfilled and in a satisfactory way?<br>• Are the plans dynamic and flexible?<br>• Are the plans lasting and robust? | • Indicators: Diversity, living conditions, etc.<br>• Use the five E's[13] of SSM |
| | Economic sustainability | | • Indicators: Realistic, payable, bottom-line, etc.<br>• Use the five E's of SSM |
| | Environmental sustainability | | • Indicators: Technical solutions, technology, impacts, self-sustaining, $CO_2$ neutrality, etc.<br>• Use the five E's of SSM |

**Table 39 Guideline questions regarding sustainable results and suggested follow up and methodology recommendations**

Figure 38 illustrates some of the elements which are important for operationalising the concept of sustainability and obtaining a sustainable transport planning process. These elements are all part of the suggested guidelines for understanding the problem situation and for obtaining a sustainable planning process, see Table 37 and Table 38.

Figure 38 furthermore illustrates that the elements are related and should be seen as a whole. The outer systems boundary is marked as dotted as the system is not seen as complete, and still awaiting further research.

[13] The five E's are a part of the measure en control in SSM described in section 2.3.3

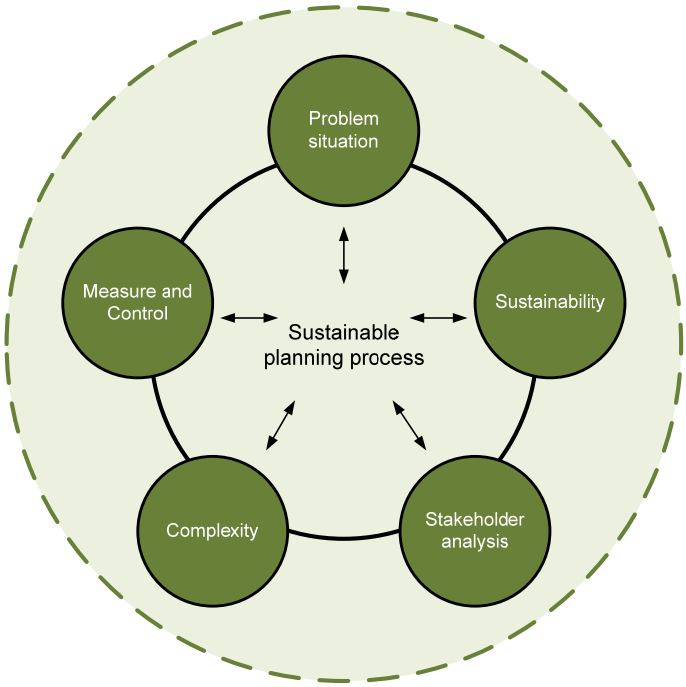


**Figure 38 Illustration of some of the elements of a sustainable planning process**

The suggested guidelines for how the concept of sustainability can be operationalised and the overview of the factors influencing a sustainable planning process can be related to the existing planning process. The guidelines concern the problem situation, the process and the results. Focus on process and results are in paper 5 (Jeppesen, forthcoming) presented as corresponding with some of the by Churchman inspired planning levels outlined by Ulrich (1988): the ideal planning and the goal-planning, see Table 40.

| Planning type | Actual mapping | Ideal mapping | |
|---|---|---|---|
| | Planning task | Planning constraints | Planning level |
| Ideal-Planning | Design ideals | Ideals, purposes, goals, and means sought | Normative |
| Objective-Planning | Determine the planning purposes to secure improvement | Ideals given, purposes, goals, and means sought | Strategic |
| Goal Planning | Define exact goals that will secure improvement | Ideals and purposes given, goals and means sought | Tactic |
| Means Planning | Means | Ideals, purposes, and goals given, means sought | Operational |

**Table 40 Overview of the four planning levels and two mapping types outlined by Ulrich (1988), content adapted from (Ulrich, 1988, pp. 425-427) and the table is presented as in (Jeppesen, forthcoming).**

Generally visions and design ideals are made on the national planning level, but can be found on the municipal level, too. The Nordhavn case, presented in paper 5, is an example of this, see section 4.10 and 4.11. Goals-planning is conducted on both the national and the municipal

level, as both levels act as road authority for different classes of roads, and thereby both have tasks to complete on the operational level. The guidelines are therefore seen as useful on both of the main levels of the Danish transport planning.

## 5.2 Discussion of the outlined guidelines

Sustainable transport planning is a very broad topic which covers many different research questions and agendas. This thesis has focused on if and how the concept of sustainability could be operationalised in strategic and complex transport planning, and has addressed whether or not sustainable transport planning regards the planning process or the results of the planning or both, see section 2.2.3 and paper 5 in section 4.10 and 4.11. The orientation influences whether there will be a need for methodologies (if process oriented) or a set of indicators (if result oriented) to measure towards, see section 5.1.

In this PhD thesis a process oriented approach was chosen in order to work with the concept of sustainability from a systems thinking perspective. An exploration of plausible methodologies was therefore conducted and this led to a consideration of application of the concept of sustainability as either implicit or explicit. In traditional transport planning the concept of sustainability tends to be used in a less than implicit way. This thesis has argued for a transparent and operational use of the concept. Clarification and definition of the use and application of the concept of sustainability are important in order to make it transparent to all parties concerning which norms, values, and worldviews are applied and in what way. Ensuring transparency is, together with descriptions of interpretation of the concept, the key to an operationalisation of sustainability in the transport planning process.

The outlined guidelines should not be seen as the only or definitive answer to how one obtains sustainable transport planning, but as a first step and a recommendation on how to get there. The guidelines are to be viewed as a help to transport planners dealing with strategic and complex problem situations, especially focusing on the process and not the results. Following the questions of the guidelines will not necessarily ensure sustainable results, but it will broaden the input and encourage planners to reflect upon the planning problem and approach to deal with it. Thus, the guidelines shall be seen as an outline, which is to be further developed in order to make them comprehensive enough to cover the, at times, abstract notion of a sustainable transport planning process. There probably never will be such as a ‘one-size-fits-all’ solution providing solutions for sustainable transport planning, as it is always a matter of worldview, norms and values.

# 6 Findings, conclusion and perspectives

This chapter presents the main findings of this PhD thesis. The findings will be based on the theoretical outline and definitions of Chapter 2, the developed methodologies presented in Chapter 3, the application of the developed methodologies to case studies as presented in the five papers provided in Chapter 4, and the guidelines formed in Chapter 5. Following, this chapter answers the research questions asked in Chapter 1, and finally the conclusion of this PhD thesis will be presented and the perspectives are outlined.

## *6.1 Findings*

An application of the, in this PhD thesis, developed methodologies to the case studies reported in paper 1, 3, 4, and 5, combined with the completion of this PhD thesis, has led to a set of six general findings, regarding sustainable transport planning, based on a multi-methodology approach to decision making:

- The *first* finding regards the use of systems thinking and multi-methodology approaches in transport planning. The two approaches have provided indications of being very useful when dealing with large, strategic, and complex transport problems, due to their abilities to analyse, structure, and debate the problem in focus.

- The *second* finding regards the amount and selection of methods, as an application of multiple methods does not hold the answer in itself. The methods need to be carefully scrutinised and selected based on their individual qualities, as too many methodologies could lead to an information overload, confusing the stakeholders and decision makers. It is furthermore found that soft or semi-soft methods can be embedded in hard systems approaches which are most commonly used in strategic and complex transport planning, (Jeppesen et al., 2008).

- The *third* finding regards the operationalisation of the concept of sustainability. It has been found that implementation of the concept of sustainability in transport planning can either be implicit or explicit. In order to gain the best understanding of the meaning of the concept in the specific case and to make the process transparent, it is important

to operationalise the use of the concept of sustainability. The concept should be operationalised at all levels of the process and in the results. This can e.g. be done by clarifying worldviews, norms, and values using a sustainability 'advocate', see (Jeppesen, 2009a).

- The *fourth* finding regards the individual needs of the applied methodologies. It is important to be aware of the strengths and limitations of the applied methodologies and to recognise beforehand which goals are obtainable and with which purpose and perspective. It is important to match the choice of methodology with the amount of participants, the types of participants, the available time, and the facilitator's skills, in order to gain the best of the methodology applied in the process, see (Jeppesen & Paucar-Caceres, 2008) and (Jeppesen, 2009b).

- The *fifth* finding regards the match between methodology choice and participants. This regards how the methods are chosen and applied in intervention. The complexity level of the problem is decisive for which analysis/methodology to apply, and the complexity and abstraction level of the methodology is determining how it is received and taken in by the participants. The complexity level and choice of methodology need to suit the participants and consideration of which abstraction level to choose is important, (Jeppesen, forthcoming).

- The *sixth* finding regards how the concept of sustainability is applied to the planning situation. When applying the concept of sustainability, it is important to clarify if the concept is applied to the process, the result, or both, as this influences both operationalisation, approach, and planning level, (Jeppesen, forthcoming).

Based on the findings it can be recommended that:

- ... the developed methods and guidelines for sustainable transport planning are used when dealing with the concept of sustainability in relation to strategic and complex transport planning problems.

- ... the proposed considerations regarding clarifying if the concept of sustainability is applied to either process or result, and what planning level it is applied to, are used by every study seeking to use the concept of sustainability.

- ... application of the concept of sustainability is done in consideration of whether or not an implicit or an explicit approach is used, and that the concept of sustainability is used in a transparent and understandable way.

The above findings and recommendations lead to the answers of the two research questions set out in Chapter 1.

According to the first question, this PhD thesis demonstrates that the concept of sustainability can be operationalised in strategic and complex transport planning and decision making through a systems thinking approach. This depends upon the use of appropriate methodologies, and the in this thesis demonstrated methodology developments resulting in semi-soft methods, CSSF, DST, and SDCs are examples of such. Depending on the choice of methodology, the operationalisation will be either implicit or explicit involving either an analyst or all stakeholders (involved and affected).

Regarding the second question, this PhD thesis demonstrates that guidelines can be formed in order to operationalise the concept of sustainability into either implicit or explicit sustainable transport planning regarding either process or results. The application area depends on the chosen planning level and objectives and thereby upon the political agenda, boundaries, and visions for transport planning regarding strategic and complex problems as well the use of the concept of sustainability.

However, the findings and recommendations of this PhD thesis are to be seen as a first step towards an operationalisation of the concept of sustainability. As previously stated there is not a one-size-fits-all solution for how to operationalise the concept of sustainability in transport planning. It is important to be aware of the special details of each planning problem, and the related visions and constraints. It is therefore also important always to consider the problem situation as a whole and clarify the stated and 'taken for granted' boundary judgements.

## *6.2 Conclusion*

This PhD thesis identified three methodologies, based on a systems thinking approach, to be useful in relation to complex transport planning. Four methodology developments are proposed in order to develop methods which are customised for an operationalisation of the concept of sustainability in transport planning. The original methodologies were SSM, CSH and DC, which were developed into four methods named semi-soft methods, CSSF, DST and SDC. These methods showed good results in the case studies where they were applied, and they form a first step towards an operationalisation of the concept of sustainability in transport

planning, though the methodologies still need further applications in order to reach their full potential.

This PhD thesis determines that the concept of sustainability can be applied as either implicit or explicit. In traditional use of the concept of sustainability, the use is often less than implicit, as it is stated that sustainability is sought but not how, where, or by whom, and neither is it transparent to see which values and norms are used. Among the four proposed methodologies two (semi-soft methods and CSSF) were identified as using sustainability consideration in an implicit way and two (DST and SDCs) were identified as using sustainability consideration in an explicit way. The sustainability 'advocate' introduced in the DST and the set of guidelines leading to sustainable transport planning can be seen as the most specific explications of the concept of sustainability provided in this thesis.

This PhD thesis has been process oriented in regard to the operationalisation of the concept of sustainability in transport planning. The approach to planning, methodologies, and guidelines focused on applying the concept of sustainability in a transparent way. The three dimensions of the concept of sustainability can, in regard to the transport planning process, be operationalised by stakeholder analysis and participation, a choice of alternatives, and a set of monetary and non-monetary criteria covering all aspects of involved and affected stakeholders of both human and non-human nature.

From the guidelines, the findings, and the answers to the research questions it can be concluded that it is possible to operationalise the concept of sustainability within strategic and complex transport planning and decision making, by using systems thinking and multi-methodology in the approach. A set of guidelines for an operationalisation of the concept of sustainability could furthermore be outlined in order to enable a sustainable transport planning process.

## *6.3 Perspectives*

This PhD thesis provides a broad foundation for further exploration and operationalisation of the concept of sustainability. The PhD thesis can be seen as an exploration of how an operationalisation of the concept of sustainability in transport planning can be approached. The guidelines, findings, answers to the research questions, and the conclusion can be seen as a first step towards a more transparent and operational use of the concept of sustainability. Suggestions for further research based on the outcome of this PhD thesis regards the following topics:

- Participative application of the CSSF to transport planning presented in paper 2. Such an application could be based on the experience gained from paper 5, where SSM was used in a semi-soft way and CSH was used for semi-structured interviews. The identified stakeholders could be brought together for a workshop planned after the CSSF. Paper 5 could then be further developed by the group synergy, joined learning about the problem situation, broader possibility for reflection based on achieving more input, and better time for the individuals to consider how they interpret the meaning and application of the concept of sustainability. A further application could concern the actual development in the Nordhavn area.

- Further development of the DST presented in paper 3 could make it more robust for use in the early planning phases. It could especially be interesting to develop the way in which the strategies, presented by the advocate, is formed and how the criteria are prioritised.

- More applications and further development of the SDC presented in paper 4. With the presented COSIMA-decision model, CBA-data is a requirement. Further development could regard researching if 'benefit analysis', without CBA data could be used in the SDCs, enabling SDCs to be used in situations where CBA data are not present.

- Applications and test of the guidelines from actual transport planners would be interesting in terms of how well the guidelines and proposed methodologies are understood, used and internalised.

The aim of this PhD thesis was to explore an operationalisation of the concept of sustainability. The conclusions presented will, if implemented, be valuable for transport planning on different planning levels. The developed methods shall, based on more applications, be refined based on the findings, but they are already implementable. Some of the ideas, especially regarding implicit and explicit use of sustainability, might even be implementable in other sectors besides transport planning.

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# Appendix overview

Appendix 1: Description of the COSIMA decision model

Appendix 2: Memorandum of the Ostlänken decision conference

Appendix 3: Memorandum of the public transport system decision conference

# Appendix 1 – Description of the COSIMA decision model

This appendix is a short step-by-step description of the decision model COSIMA (COmpoSIte Model for Assessment) used in both the DST and as a tool for on-the-spot-modelling in the DCs presented in this thesis. This appendix presents a step-by-step description of COSIMA in order for the reader to understand what the model does. The appendix is concentrated on descriptions of input and procedures so this will not seem as a black box removing focus from the real objective of this thesis, i.e. the processes where the decision model is used. In general the decision model theory, techniques and design are taken as granted and used merely as a tool in order to analyse and develop the proposed processes of semi-soft methods, DST and SDCs.

The COSIMA decision model consists of a series of well defined theories and techniques. The applied theories and techniques are not described in full detail, but references for further reading are provided at relevant places. The theoretical considerations behind the theories and techniques are not an issue in this thesis as COSIMA has been used in many projects and the development of the model, the theory, technical features and results are described in several papers and reports, see among others (Leleur et al., 2007), (Salling et al., 2007), (Leleur, 2008) and (Hiselius et al., 2009).

The COSIMA decision model was developed at Centre for Traffic and Transport (CTT) (now DTU Transport) at the Technical University of Denmark. The main idea of COSIMA is to provide an opportunity to combine cost-benefit analysis (CBA) with multi-criteria analysis (MCA), providing the user the opportunity to conduct a measure of attractiveness of a given alternative based on both monetary and non-monetary effects. Attractiveness is measured as a rate above 0, where the higher the number, the higher attractiveness.

The COSIMA decision model is based on the following equation:

$$TRR(A_k) = \frac{1}{C_k} \cdot \left( \sum_{i=1}^{I} V_{CBA}(X_{ik}) + \alpha \cdot \left[ \sum_{j=1}^{J} w(j) \cdot V_{MCA}(X_{jk}) \right] \right)$$

| | |
|---|---|
| $\alpha$ | The calibration factor that expresses the model set-up's trade off between the CBA and the MCA |
| $A_k$ | Alternative k |
| $C_k$ | The total costs of alternative k |
| $TRR(A_k)$ | Total rate of return for alternative k |
| $V_{CBA}(X_{ik})$ | The value in monetary units for the CBA impact *i* for alternative *k* for altogether *I* CBA impacts |
| $V_{MCA}(X_{jk})$ | The value-function score for MCA criterion *j* for alternative *k* for altogether *J* MCA criteria |
| $w(j)$ | The weight that expresses the importance of criterion *j* |
| $X_{ik}$ | CBA impact *i* with regard to alternative *k* |
| $X_{jk}$ | Criterion *j* with regard to alternative *k* |

The procedures of the COSIMA decision model (the generation of the input for the equation and the calculations with it) will in this appendix be described in verbal terms, by instruction of what is done in which order, by whom and what happens with this information.

Definition of inputs for the COSIMA decision model:

- **Alternatives**: The alternatives describe the different *solutions* to the task. Each of the alternatives must have specific individual characteristics and detailed descriptions of their content. Furthermore information about costs and benefits is required in form of total costs and benefits from a CBA. The alternatives can be predefined by the decision makers or be defined by the analyst of the DST or the participants of a DC. In transport matters the alternatives will usually be predefined by the municipality, the ministry or otherwise.

- **Criteria**: The criteria describe the effects/impacts under which the alternatives are evaluated. The criteria must all be well defined and verbally described in detail, so that no confusion regarding their meaning, content or interpretation can occur. The criteria must not overlap as that will make them difficult to separate and thus minimise their ability to segregate between the alternatives. It is also important to define the criteria so there is no overlap with the effects used in the CBA as such an overlap will result in double counting, see (Leleur, 2008). The criteria can either be 'pre-defined' by an EIA or other documents or they can be defined by an analyst (e.g. as in a DST) or by the participants in a DC.

- **MCA-%**: The multi-criteria analysis-% (MCA-%) is used when the monetary and non-monetary parts of the COSIMA analysis are combined. The MCA-% describes the

relative weight of the MCA-part towards the CBA part. The traditional monetary input from the CBA part (the B/C-rate) will never be removed or change; it will merely get an addition from the MCA in the computation of the attractiveness level expressed by the TRR. If the CBA and the MCA part are seen as equally important the MCA-% is set to be 50. If the MCA-% is below 50 the CBA part is regarded as more important than the MCA part and if the MCA-% is above 50 the MCA part is set to be more important than the CBA part, see (Leleur, 2008).

Definition of actions conducted when applying the COSIMA decision model:

- **Criteria weights (here in form of prioritising of criteria)**: The defined criteria are prioritised w(j) due to their importance. The criteria are ranked with the most important first (No. 1) and the second most important as second (No. 2) etc. This is done by the analyst in the DST according to the defined strategy or by the participants in a DC. This direct prioritising of the criteria is based on the SMARTER technique (Goodwin & Wright, 2004). Accordingly, the criteria are assigned individual weights (based on their priority). These weights are surrogate weights based on the Rank Order Distribution theory (ROD-weights) (Roberts & Goodwin, 2002). The weights are dependent on the number of criteria, see Table 41, see (Roberts & Goodwin, 2002).

| | | Number of criteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| ROD weight for priority No. | 1 | 0,1867 | 0,2058 | 0,2292 | 0,2590 | 0,2966 | 0,3471 | 0,4180 | 0,5232 | 0,6932 | 1 |
| | 2 | 0,1667 | 0,1808 | 0,1977 | 0,2174 | 0,2410 | 0,2686 | 0,2986 | 0,3240 | 0,3068 | |
| | 3 | 0,1466 | 0,1565 | 0,1672 | 0,1781 | 0,1884 | 0,1955 | 0,1912 | 0,1528 | | |
| | 4 | 0,1271 | 0,1332 | 0,1375 | 0,1406 | 0,1387 | 0,1269 | 0,0922 | | | |
| | 5 | 0,1081 | 0,1095 | 0,1084 | 0,1038 | 0,0908 | 0,0619 | | | | |
| | 6 | 0,0893 | 0,0867 | 0,0805 | 0,0679 | 0,0445 | | | | | |
| | 7 | 0,0709 | 0,0644 | 0,0531 | 0,0334 | | | | | | |
| | 8 | 0,0527 | 0,0425 | 0,0263 | | | | | | | |
| | 9 | 0,0349 | 0,0211 | | | | | | | | |
| | 10 | 0,0173 | | | | | | | | | |

**Table 41 Allocation of ROD weights, dependent on the number of criteria, based on (Roberts & Goodwin, 2002)**

Table 41 presents the ROD-weights based on the number of criteria and their priority. The ROD-weights shown can be applied to cases with a maximum of ten criteria. When assigning

the weights, the column with the appropriate number of criteria is chosen. The weights shown in this column are assigned to the criteria. The highest weight is given to the criterion with the highest priority (No. 1), the second highest to the second most important criterion (No. 2) until the lowest weight is given to the criterion with the lowest priority.

- **Scoring of alternatives (here in the form of direct rating using pairwise comparisons)**: A pairwise comparison describes the task when two alternatives are compared to each other with regard to how well they perform under a given criterion. All alternatives are compared with each other under each of the criteria. The comparisons are based on the REMBRANDT technique (Olson et al., 1995). The comparisons are conducted by either the analyst (e.g. of a DST) or the participants of a DC. The REMBRANDT technique provides the scale, see Table 42, for the comparisons. The analyst or the participants use the verbal description for the analysis of and when accommodation is reached for how the alternatives perform the model technician transforms the verbal description into its numeric description, which is entered into the COSIMA decision model.

| Verbal description | Related value |
|---|---|
| Indifference | 0 |
| Weak preference | 2 |
| Definite preference | 4 |
| Strong preference | 6 |
| Very strong preference | 8 |

**Table 42 The REMBRANDT scale - verbal and the numeric translation, adopted from (Olson et al., 1995)**

The number of pairwise comparisons which must be conducted under each criterion can be calculated by the formula: $\frac{n \cdot (n-1)}{2}$, where n is the number of alternatives, see (Saaty, 1977) and (Belton & Stewart, 2002). Depending on the number of alternatives and the number of criteria this task can be quite demanding and time consuming.

In special cases where the criteria have been predefined in an EIA, the professionals who made the EIA might also have made some kind of comparison of the alternatives which can be used as direct, or indirect input for the pairwise comparisons. This sets focus on the quality of the EIA documentation (or other documents) and the descriptions of the outcome of the comparison, see paper 3 in section 4.6 and 4.7.

- **Value function scores ($V_{MCA}(X_{jk})$)**: Based on the pairwise comparisons a set of value function scores can be calculated for each of the alternatives under each of the criteria. First the pairwise comparisons are transformed using the REMBRANDT technique. For each row in the transformed matrix a multiplicative-score is calculated using the geometrical mean method. The multiplicative scores are normalised resulting in REMBRANDT scores, which is used to assign value function scores to the alternatives. The value function scores lie between 0-100. The criterion with the highest REMBRANDT-score is assigned the value 100 and the criterion with the lowest REMBRANDT-score is assigned the value 0. The scores for the criteria in between are assigned values between ]0,100[. These value function scores are calculated by linear interpolation, see (Leleur, 2008). The value function scores are used in the subsequent calculations.

- **Calibration (the α-indicator):** A series of calculations are conducted for each of the alternatives under each of the criteria. First the value function scores and previous assigned criteria weights are used to calculate the shadow prices of the individual criteria. To do so, the best performing alternative in the CBA is used for calibration. In some cases another calibration process can be recommended, see (Hiselius et al., 2009). The calibration is based on the chosen MCA-%. If the MCA-% is set to be 50 the total MCA value shall equal the total benefit of the alternative. This principle leads to shadow prices for the criteria, see (Leleur, 2008).

- **Calculations:** The shadow price set for each criterion is used to calculate the value of each of the alternatives for each of the criteria. The values for each alternative are summed to obtain the total MCA value. The total MCA is then added to the total benefit of the alternative to obtain the total value. Finally, the total value is divided by the cost of the alternative in order to obtain the TRR of the alternative. This procedure is conducted for each of the alternatives to obtain a TRR of each alternative, see (Leleur, 2008).

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# Appendix 2 – Memorandum of the Ostlänken decision conference

Held on the 27th of January 2009, Norrköping, Sweden
Part of the Vinnova project, see (Hiselius et al., 2009)
Used in paper 3 and 4

The participants were welcomed and introduced to the research group conducting the decision conference and to the research project for which it was conducted. As part of the introduction to the research project, the decision makers were informed that the focus was upon the process and not on the case. The Ostlänken case on which the participants were experts served to test the process and get feedback from participants. The participants were furthermore reminded that they were invited as 'themselves' and not as the organisations they usually represented, so they could state their 'expert' opinion without getting referred to by name as their identity would be kept anonymous in the reporting from the intervention. The results obtained from the decision conference are based on the preferences of the participating stakeholders. Then a short introduction to the programme, the decision conference and the decision problem was given.

Following this, the actual decision conference was started by asking the participants to have a group discussion regarding the importance of the defined evaluation criteria. The participants were asked to find consensus, but it turned out that finding consensus was not the first task to solve. The participants were more eager to discuss the content of the criteria, as they believed that the criteria could not be split up as they were in the EIA-report, as that would make them object oriented. For instance the natural environmental and the cultural environment should be interrelated and seen as a whole. Due to the time constraint and the decision made in the planning phase to use the EIA-report as initial input, the facilitator decided that this subject was not to be addressed at this time. It could be dealt with at the end of the decision conference if there was any time left or it could be subject to a longer and more in-depth version of the decision conference - preferably with more participants. This led to a group discussion ending in a consensus about how to prioritise the criteria. The model-technicians applied the prioritised list to the COSIMA-model. To compensate for the variance in how the participants individually wanted to prioritise the criteria, and to enable the participants to make several criteria equally important, the participants were also asked to fill in a scheme

indicating their personal prioritising of the criteria. It should be noted that none of the participants had the criteria, which was the most important in the consensus, as their highest prioritised criterion. This is interesting as consensus was reached in the group decision. This could have been a result of all the participants giving in a little to reach consensus, so no one got their preferred prioritisation but everybody got something they could accept. It can also be a result of the group consensus illustrating that the criteria should be joined into fewer interrelated criteria. Last it can be a result of the facilitation, though the facilitator followed the guidelines on being neutral and working only as a catalyst for the process. The individual prioritising was like the group prioritising entered into the COSIMA-model.

Following this initial task, the participants were asked to conduct complete pair-wise comparisons of all the corridor alternatives towards all the criteria. The participants were to use a verbal scale to state how one alternative was performing towards another alternative under a given criterion. The process was guided by the facilitator using PowerPoint slides to present the comparisons one by one. The slides in sequence presented which corridor alternatives were being compared under which criterion, the specific characteristics of the corridors and the verbal comparison given in the EIA report. This was a very long process with eight criteria and six comparisons under each criterion creating all together 48 comparisons. The participants were very engaged in the process and had long and in-depth discussions about almost all the comparisons. Especially as concerns the first two criteria the discussions were long and thorough. This was due to the topic of the criteria and a result of getting used to the process. The comparisons were seen as an enlightening process as the participants in several of the comparisons chose to change the performance of the corridor alternatives compared to the assessment in the EIA report. The deviations from the EIA report were surprising, but underpinned that the participants stated their own opinion as experts and did not hold on to the official opinions of their organisations. The results of the 48 pairwise comparisons were entered into the COSIMA-model when the discussion of each comparison was finished.

When all the pairwise comparisons were completed, the participants were introduced to the CBA–results (which they had been provided with on beforehand) and informed about the theoretical understanding of the concept MCA-%, which they were to decide about afterwards. The group discussion very soon led to a consensus of working with a MCA-% of 50, and this was also the initial preference of all the participants.

All the inputs were computed in the COSIMA-model as part of the on-the-spot modelling and the resulting output was presented as a Total Rate of Return (TRR) graph indicating how the corridor alternatives performed at different MCA-% values. The resulting output from the

COSIMA-model was calculated both as a group consensus and with the stakeholders' individual preferences regarding the prioritising of the criteria. Interestingly the individual graphs of the TRR showed the same tendencies as found for the group consensus. In all cases the red corridor alternative was the most preferable under low MCA-% values and for higher MCA-% values the blue corridor alternative with the short tunnel was the most interesting. The tipping point varied slightly between the group consensus and the three individual TRR graphs.

The case results were presented and discussed. The participants found it interesting to see the results of their discussions computed and presented as a graph of the TRR values. The presentation of the results was followed by a discussion of what this meant and how the participants' opinions were reflected in the four resulting TRR graphs. This was followed by a general discussion of the decision conference process and if the participants felt anything had been left out or if anything could be improved. The participants were in general very positive regarding the process, but there were a few comments about the choice of criteria. They would have preferred to have defined the criteria in another way - as they saw the EIA criteria as object-oriented and not encompassing all impacts. Some of the proposed criteria could be merged into more comprehensive criteria, e.g. a more holistic approach to the natural and cultural landscape. The large amount of travellers envisaged was also mentioned as they would be affected during their journey, and it was suggested that some of the criteria should take care of their interest too.

The final discussion ended with an evaluation scheme. The participants were asked anonymously to rate 12 statements regarding the decision conference. The statements covered both their preparation for and attendance in the decision conference. The participants were among other things asked if they felt they were well prepared, if they understood the process and outcome, if they would like to attend a similar conference if invited even if it might be longer, if they would encourage colleagues to attend a similar session and very important, if they could see a decision conference as a common part of a planning and decision making process. The participants were very positive towards almost all questions. They had no negative answers and were only indifferent in a few cases. In sum, many felt they had gained a lot of information from participating. Most importanty they expressed interest in having the opportunity for stakeholders to participate in the decision making and discuss both monetary and non-monetary inputs in a structured way, which could lead to better decision support for the decision makers. The ½ day decision conference was ended by summing up the tasks, results and final comments and thanking the attendees for their participation and involvement in the discussions.

## References

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# Appendix 3 – Memorandum of the public transport system decision conference

Held on the 20th of April 2009 in a Swedish town
Part of the Vinnova project, see (Hiselius et al., 2009)
Used in paper 4

The meeting room was organised with chairs and tables set in a way so all the participants were placed around the same table facing the PowerPoint presentation and with a good view to the surrounding walls which were to be used for hanging up the posters produced during the session. The table was set with water, glasses, fruit and sweets. Furthermore maps with the three alignments were placed on the table for the participants to use throughout the decision conference. 11 persons were supposed to attend, but one person had to cancel. All participants can be denoted as experts/professionals.

The practitioners were first welcomed and introduced to the research project which the decision conference was a part of. Before start, the organiser from the steering group announced that they would like to begin with a short presentation of what they had been working with. This was of course allowed, even though the programme was quite tight. Afterwards the participants were introduced to the team of the three persons carrying out the decision conference (the research project leader, the facilitator and the model technician).Then the participants were asked to present themselves by telling their name and their affiliation and interest areas. With the introductions completed, the participants were introduced to the overall elements of the day. This was followed by a short introduction to the concept of a decision conference and the participants were told that they were expected to participate actively in the process. After the introduction to the research project and its aim, an outline of the programme was presented to the participants with the main agenda elements and no time indications.

From here the decision conference could start. The three alternative light rail lines were sketched, but no further introduction was needed as the participants were all well acquainted with the alignments, specifications and available information regarding these. After this the participants were introduced to the content of the cost benefit analysis (CBA). The CBA was known to the participants, but the included elements were sketched in order to make the content of the CBA present in order to avoid having several criteria concerning the same

effects and thereby resulting in double-counting of these effects. After the brief introduction the participants were presented with their first task. This task concerned the definition and choice of criteria to be used in the subsequent multi-criteria analysis.

The planning group from the municipality had, as part of their work with the criteria, defined a number of non-monetary criteria. These had beforehand been compared to the content of the CBA and some overlap had been found. This could lead to double counting and the participants therefore were asked to reconsider the criteria one by one and agree upon whether or not they wanted to use each of the criteria. They were given the opportunity to use them as they were, redefine the original criteria or leave them out. If they were uncertain, they could keep the criteria and decide later on in the process if they were to be merged with other criteria or finally be left out. Only a few were left out and others were considered for rewriting due to the risk of double counting and inconsistent content. The decision of which criteria to bring along, change and leave out was carried out as a debate around the table. The participants led the debate themselves, and those not stating their opinion were encouraged to do so by the facilitator. The criteria which were chosen with no hesitation and the ones that should be debated were one by one noted on a large Post-it and placed on the wall at the end of the process. A set of criteria to be used when appraising public transport assessments has been worked upon in the Vinnova research project as a list to be used when undertaking such assessments (Hiselius et al., 2009). The list was presented to the participants and they were asked to consider if any of these criteria would be of interest for the ongoing assessment. Only very few of the proposed criteria were included as many of the mentioned subjects were already covered, but the list served as an inspiration for the final concretising of the chosen criteria. Once again the decision was taken as a part of a group debate and the chosen criteria were listed on a large Post-it which was placed on the wall at the end of the task. The task resulted in many comments relating to the criteria which the group had worked on during their previous planning work. Finally the resulting two lists were placed on the wall: one with the participants 'original' proposed criteria and one with the new additional ones. The two lists together provided the complete set of non-monetary criteria to be considered in the following process. Finally the lists were placed above each other in order to form a joint list with a total of 14 criteria.

At this point the participants needed a coffee break. This was a bit ahead of the plan, but was incorporated as part of the next task. After a short break the participants were invited to bring their coffee cups with them and stand around the list of criteria hanging on the wall. There was a total of 14 criteria. The participants were provided with one set of little Post-it notes numbered 1-14 which they were to place on the list on the wall, indicating the importance of each of the criteria. This was a group exercise where one person or several persons with a

shared opinion would place one Post-it note with a number and then, if someone could not agree, they would have the opportunity to protest, state their opinion, and the group would together find a solution to whether or not the criteria had been appointed the suiting rank or it should be changed (up or down). At the end of the initial sorting of the criteria due to their importance (with the most important with rank 1 and the least important with rank 14) not all participants felt that the sorting had resulted in all criteria having the right rank. The participants finding that the sorting was not finalised were asked to state their opinions and the group sorted the inconsistency by finding accommodation for a near to final rank. One of the participants found this approach highly undemocratic and would have preferred a vote, leaving the prioritisation to a choice of the majority and not a group decision. The facilitator explained the value of a group process and invited the participant to put forward his opinions and thereby influence the final prioritising. Before the ranking session was finalised the participants were told that only the ten highest ranking criteria were taken into consideration in the model. The limitation on the number of criteria was set due to the limitations in the model where criteria beyond ten cannot be assigned a weight. Technically, 'the tenth' criterion weights so little that any following (and lower) weight would be insignificant in the following modelling process. Bringing forward only the ten highest prioritised weights resulted in a few adjustments of the content of some of the criteria, but caused no changes to the prioritising. A final list of the chosen criteria was made representing them in the rank order representing their importance.

The criteria list was then to be concretised so its content would be well defined for the process to follow. The concretising of the criteria was completed jointly by the group of participants, discussing words which defined the content of each criterion. A large Post-it was created for each criterion, stating the name of it and the index words. The criteria were defined one by one starting with the one of the highest rank. At the end, the criteria descriptions were placed on the wall besides the prioritised criteria list. Due to the very short time assigned to conduct the DC, this task was not completed with such in-depth discussion as could have been useful. The process could therefore be seen as only half completed, as the criteria were further defined but the content continued pulling in two directions in order to have 'everything' included. Because of the lack of time, several participants commented that it had been an enlightening experience to work with the criteria again, and that the ones the steering group of the planning projects had come up with beforehand could benefit from a new round of thinking as they had realised that some important effects had been left out. As a final task in the work with the criteria, the participants were asked to provide their personal prioritising of the criteria and weigh their importance by applying a weight of 100 to the most important and a relative weight compared to this to the less important criteria, ending up with 'the tenth' prioritised criterion having the lowest assigned weight. The participants were given a scheme to fill the information into and after completing the task the schemes were handed over to the model technician.

Having worked with generation, prioritising and definition of the criteria, it was now time for the participants to make pairwise comparisons of each of the alternatives under each of the criteria. First the participants were introduced to the comparison scale and the comparison matrix. Then the concept of pairwise comparisons was demonstrated using a football example from the ongoing qualification to the world championship in football (with Sweden competing with Portugal and Denmark for qualification and the relative strength of the teams commonly known). Following this, the criteria were compared one by one under each criterion starting with the highest prioritised one. The participants were asked to consider which alternative was the better under each criterion and to use the defined scale to state if the alternatives were even, or if one was better than the other and then in this case what the difference was. For two criteria the background information could be used directly to conduct the pairwise comparison. The participants were introduced to this information as they reached such criteria.

After completing the pairwise comparisons, the participants were introduced to the term MCA-% and its technical meaning was described. When everybody had got hold of the concept the participants were each asked to state their personal preference on a distributed hand-out. The individual suggestions were gathered and handed in for the model technician for use when completing the sensitivity analysis at the end of the DC process. Afterwards the participants were asked to argue for their choices and to try to reach a group decision. Rather different numbers were presented for the MCA-% ranging from 40 to 75. Only one participant was below 50, several were at 50 and a few were above. After a while, accommodation of 60 was reached. The participants settled on 60 for two reasons. This was very close to accommodate all participants and the time constraint forced the process not to keep this discussion for too long. This led to the second break during which the model technicians filled in the final information and made the calculations.

Following the break, the participants were introduced to the resulting graph of the group process. The facilitator described the axes of the graph, where the CBA result could be seen and a presentation of what the recommendation solely based on the CBA results would have been. Afterwards the result of the group process was described and the recommendations following the proposed MCA-% were identified. This case showed that one of the three alternatives turned out to be the best performing at all MCA-% levels and that this alternative also was the one recommended by the CBA. The facilitator explained to the participants that with the chosen criteria, their prioritising, and the conducted pairwise comparisons of the alternatives, they had revealed a very robust decision.

If there had been more time available, the individual results of the participants could have been discussed one by one. In this case it was, due to the available time, chosen only to show

the individual results differing the most from the result of the group process. There was a clear tendency in the individual prioritising pointing in the direction of the group process. All participants but one had more or less the same priority of the criteria as the group. As the pairwise comparisons were only carried out as a group process, these are the same for all participants and all the individual TRR graphs were calculated for MCA-% 0-80. 9 of the 10 individual TRR graphs gave the same order of the alternatives for MCA-% from 0-80. The TRR to each MCA-% varied a bit. Only one of the ten individual graphs had a change in attractiveness within the MCA-% interval 0-80. After the presentation of the results a discussion of these was initiated around the table. The discussion covered the outcome of the DC and the found robustness of the result based on the alternatives not shifting attractiveness during the presented MCA-% interval.

After this the participants were given an evaluation form, in which they were asked 12 questions regarding the DC and their preparation and participation. Additional comments were also invited. The evaluations were very positive and almost all participants felt that they had gained a better understanding of the decision problem from their participation in the DC. If there had been more time, a 'Round-table'-talk had been planned for, so the subjects of the evaluation scheme could have been further elaborated, and the participants could have discussed their individual experiences. This had to be left out and the intervention was then at its end. Before the participants left they were thanked for their participation, told about the next steps of the research project and the further possibilities of incorporating DC in transport planning. Finally, the participants were provided with little gifts as an acknowledgement of their participation and told that they would receive the results of the DC in a couple of days by email.

Following the DC, the participants of the steering group asked if the produced posters could be left in the room for their following meeting as they had been very inspired by the debate regarding the criteria and wanted to continue the work with further specifications of the criteria.

After the DC several participants wanted to have a further discussion of the experience and they had several more comments about the intervention. Especially the criteria were further discussed, and more ideas came up which could have been useful during the DC. One example was an idea for a criterion regarding how the new light rail lines are received by the public/press which could influence the implementation.

**References**

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DTU Transport performs research and provides education on traffic and transport planning. It advises the Danish Ministry of Transport on infrastructure, economic appraisals, transport policy and road safety and collects data on the transport habits of the population. DTU Transport collaborates with companies on such topics as logistics, public transport and intelligent transport systems.

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